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COMPARISON OF WILD-DOMESTIC SHEEP INTERACTION POLICIES IN  
BIGHORN DISEASE OUTBREAK LOCATIONS IN THE CONTINENTAL U.S.,

1990-2010

By

TRISTAN ANDREW HOWARD

Bachelor of Arts in Geography, Humboldt State University, Arcata, California, 2009

Thesis

Presented in partial fulfillment of the requirements for the degree of  
Master of Science in Geography, Community and Environmental Planning

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## ABSTRACT

Howard, Tristan, M.S., Spring 2013

Geography

Comparison of Wild-Domestic Sheep Interaction Policies in Bighorn Disease Outbreak Locations in the Continental U.S., 1990-2010

Committee Chair: David Shively

For over 100 years, disease has significantly limited bighorn sheep (*Ovis canadensis*) in the western U.S. Interaction with domestic sheep (*Ovis aries*) has been a primary cause of fatal bighorn disease (typically pneumonia), which has severely reduced or eliminated entire populations. Various wild-domestic sheep interaction policies exist to address the disease problem. In this analysis, six case study locations are compared and analyzed in an effort to evaluate policy efficacy. Locations examined and their bighorn die-off dates include: the Tobin Range, NV (1991); Aldrich Mountain, OR (1991); the Highland/Pioneer Mountains, MT (1994-1995); the Tarryall/Kenosha Mountains, CO (1997-2000); the Hays Canyon Range, NV (2007); and Bonner/West Riverside, MT (2010). Each location is investigated based on the policy analysis criteria of: buffer zones, herder supervision rules, trailing restrictions, consideration of domestic sheep presence prior to bighorn reintroduction, grazing allotment alteration efforts, education/negotiation attempts, fatal removal of bighorns near domestic sheep, coordination/tension between agencies, and funding difficulties. Regarding wild-domestic sheep interaction, all locations lacked clear buffer zones and trailing restrictions. At least five locations lacked funding difficulties. Where applicable, in four locations, domestic sheep presence was considered before reintroducing bighorns. In at least two locations, grazing allotment alteration was attempted, and bighorns were fatally removed. In at least five locations, agencies coordinated bighorn management, and negotiation or education was attempted. Tension between agencies existed in at least one location. From 1990-2010, the wild-domestic sheep disease issue gained prominence in policy documents, politics, and in the minds of agency biologists. This project's case studies illustrate that bighorn-domestic sheep interaction policies can be successful with diligence, but success is unpredictable and location-dependent. If bighorns and domestic sheep are to coexist in the same areas, one size-fits-all separation policies covering the entire American West will not be effective. In a strictly ecological context, not allowing domestic sheep and bighorns to share the same ranges at all is the least risky and most effective way to prevent bighorn die-offs caused by domestic sheep disease.

“Scientific research supports a finding that when bighorn sheep intermingle with domestic sheep, large numbers of bighorn sheep die. While the exact reason for this result may be in question, it is clear that the die-offs occur. An incompatibility exists between the two species and there is no way to avoid the incompatibility other than to keep the domestics and the bighorns separate.”

——United States Magistrate Judge Donald C. Ashmanskas, *A Review of Disease Related Conflicts Between Domestic Sheep and Goats and Bighorn Sheep* (USFS 2008)

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## **ABBREVIATIONS**

ASI	American Sheep Industry Association
BLM	Bureau of Land Management
CDFG	California Department of Fish and Game
CDOW	Colorado Division of Wildlife
DBC	Desert Bighorn Council
DSEIS	Draft supplemental environmental impact statement
ESA	Endangered Species Act
FEIS	Final environmental impact statement
MFP	Management framework plan
MFWP	Montana Department of Fish, Wildlife, and Parks
MPRD	Missoula Parks and Recreation Department
NBU	Nevada Bighorns Unlimited
NDFG	Nevada Department of Fish and Game
NDOW	Nevada Department (or Division) of Wildlife
ODFW	Oregon Department of Fish and Wildlife
PRMP	Proposed resource management plan
RMP	Resource management plan
ROD	Record of decision
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WAFWA	Western Association of Fish and Wildlife Agencies
WSA	Wilderness Study Area
WSF	Wild Sheep Foundation
WSWG	Wild Sheep Working Group

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## Chapter I: Introduction

### Problem Statement

For over 100 years, disease has significantly limited bighorn sheep (*Ovis canadensis*) in the western U.S. (Tomassini et al. 2009; Valdez and Krausman 1999). Interaction with domestic sheep (*Ovis aries*) has been a primary cause of fatal bighorn disease outbreaks, which have severely reduced or wiped out entire populations (Tomassini et al. 2009; Toweill and Geist 1999). In a U.S. Forest Service (USFS) document covering the wild-domestic sheep disease issue, experts emphasize the severity of the problem. Wildlife biologist Valerius Geist notes: “Domestic sheep are virtually toxic to bighorn sheep. The two species have to be kept apart and cannot be permitted to share any common ground” (USFS 2001, 4). Veterinarian William J. Foreyt states: “If the wildlife management objective is to keep bighorn sheep alive, absolutely no physical contact with domestic sheep should be permitted” (USFS 2001, 4).



Figure 1.1. California bighorn rams in southern Oregon. Photograph by author.

Bighorns are vulnerable and valuable wildlife, so a problematic fact is that preventable wild-domestic sheep interaction regularly kills large quantities of bighorns (Valdez and Krausman 1999; ODFW 2003; Wehausen, Kelley, and Ramey II 2011). The disease problem continues to persist, largely because bighorns and domestic sheep share substantial portions of range. A series of maps produced by the Bureau of Land Management, the USFS, and the Western Association of Fish and Wildlife Agencies illustrate this trend (WSF 2012a; bighorndiseaseinfo.org 2012).

The disease problem is complicated by the fact that bighorns and domestic sheep range over a mosaic of land owned by different entities. Such distribution brings up the concept of environmental federalism. More specifically, according to natural resources policy expert Martin Nie, the issue with bighorns and domestic sheep relates to wildlife federalism, which involves complications associated with private, state, and federal control over wildlife habitat (April 26, 2013, e-mail message to author). According to Anderson and Hill, federalism has “allowed competing sovereign states to pursue their own policies for most issues” (1996).

Federalism has played a key role in U.S. wildlife management (Rasband, Salzman, and Squillace 2009). According to Rasband, Salzman, and Squillace, “through the nineteenth century the law recognized that the state had authority to regulate wildlife within its boundaries on behalf of the people of the state. . . (2009, 338). In *Geer v. Connecticut* (1896), the Supreme Court upheld the state ownership doctrine, but later Supreme Court cases weakened state control over wildlife and affirmed “the right of the [federal] government to regulate wildlife under its Property Clause power . . . and Commerce Clause power” (Rasband, Salzman, and Squillace 2009, 339). The Supreme

Court abolished the state ownership doctrine with *Hughes v. Oklahoma* (1979) (Rasband, Salzman, and Squillace 2009). Nonetheless, Rasband, Salzman, and Squillace add: “Despite the demise of the state ownership doctrine, it is important to remember that most wildlife regulation still occurs at the state level, albeit those regulations are always susceptible to preemption by a conflicting federal law” (2009, 339). The state ownership doctrine involves federalism. According to Anderson and Hill: “Federalism contrasts with the current system of political centralization, in which a national government delegates powers to state and local governments acting as the agent of the former. Under federalism, the power emanates from the state rather than from the national government” (1996).

In dealing with bighorn-domestic sheep separation issues, intermixed land ownership causes wildlife federalism difficulties. According to Anderson and Hill: “Wildlife management can be even more complicated when species range over territories larger than a state. In these instances, the optimal locus of governmental regulation may be regional, national, or even international” (1996). Bighorns are such a species, which makes it harder to effectively manage their interaction with domestic sheep with properly coordinated jurisdictional authority both within and across state boundaries.

### **Research Question**

How effective have government management policies—in different geographic regions and at different times—been in reducing the risk of disease transmission from domestic sheep to bighorns? Answering this question reveals strengths and weaknesses of wild-domestic sheep interaction policies. For the purposes of this study, a policy possesses degrees of efficacy if it separates bighorns and domestic sheep such that no

disease exchange occurs, or transmission is delayed or mitigated. A policy can be considered ineffective if it fails to prevent wild-domestic sheep interaction and disease transmission.

More policy weaknesses than successes were revealed with this study because it focuses on areas that experienced outbreaks—and the occurrence of a disease outbreak often indicates ineffective policy. Evaluating policy efficacy (including degrees of ineffectiveness) is this project’s foremost focus. Among factors contributing to bighorn illness, management policies have some of the greatest potential to prevent infections. Preventing bighorn sickness is often in the best interest of the public because of bighorns’ ecologic, economic, and aesthetic and intrinsic importance. Thus, it is vital to better understand the bighorn-domestic sheep disease issue in an effort to preserve and maintain a valuable wildlife resource.



Figure 1.2. Domestic sheep graze near Grand Junction, Colorado. Photograph by Natural Resources Conservation Service (NRCS 2012a).

## Objectives

This project's primary objective is to help scientists and public land managers gain a better understanding of wild-domestic sheep interaction policy efficacy. It accomplishes this objective by using an analysis of policies in six different case study locations to provide information on how policy and patterns of land ownership and management influence bighorn-domestic sheep disease transmission.

This research could aid wildlife managers and conservation organizations with public outreach efforts. The fact that domestic sheep are one of the most significant killers of bighorns does not seem to be common knowledge to the public. Thus, this study could help agencies and advocacy groups transmit information to target audiences. Among those target audiences, one of the most important is domestic sheep owners who live in bighorn habitat. This document provides information cogent to both wild *and* domestic sheep advocates. It also serves ecology and policy researchers as a useful information resource.

Information gathered for this thesis has been available to the public in a synthesized form for months because research for this project led to the accumulation of substantial amounts of data that were used by the author for the construction and maintenance of an educational website (Disease Transmission from Domestic Sheep to Bighorn Sheep; <http://www.bighorndiseaseinfo.org>). The site focuses on numerous facets of the bighorn-domestic sheep disease issue. However, it is not part of the original research design for this study. It is a research byproduct. It has also not been peer-reviewed, and it is not affiliated with The University of Montana.



In summer 2012, a link to the site was shared with about 40 advocacy groups, including bighorn conservation and domestic sheep production organizations. Thus, to some extent, project objectives have already been fulfilled because the website has been linked to and recognized by important organizations, such as the Wild Sheep Foundation (foremost bighorn advocacy group in North America) and Western Watersheds Project (successful and litigious environmental advocacy group based in Idaho).

Other objectives of this thesis are to fill gaps in geographic and wildlife management literature. These objectives have been accomplished, as is explained at the beginning of Chapter II.

### **Thesis Structure**

This thesis is organized into six chapters that contain numerous sections. After this introduction, Chapter II presents important background information on the wild-domestic sheep disease issue. This background provides an overview of how this project fits into the disciplines of geography, wildlife management, and wild-domestic sheep management. It also covers interaction management policies and the controversy associated with such management. Reading this background material is important if one is to gain full insights from this study. The background is lengthy because bighorn-domestic sheep interaction management policy involves complicated issues demanding rich exposition with a wide geographic-temporal scope for proficient understanding.

Chapter II also provides facts about bighorns, including subspecies and ranges, population history, importance, and the biology of the bighorn-domestic sheep disease connection. It also includes a review of the relevant literature on this topic that is grounded in the disciplines of geography and wildlife biology. Chapter III covers the

methodology employed for this study and discusses how and why various research and analysis methods were utilized. More detail on the organization of Chapters IV and V is explained in Chapter III.

Chapter IV is the most substantial part of this thesis. It features case study results for six locations. These location-specific results are presented under various categories, ranging from biophysical geography and land ownership (summarized in each location's introduction) to policy analysis criteria. Chapter V presents a discussion of the results showcased in Chapter IV. The discussion emphasizes how findings reveal and illustrate policy efficacy trends. Chapter VI examines the relationship of this study's findings to management approaches. It also discusses this project's shortcomings and the need for additional research. Furthermore, Chapter VI features the conclusion and takeaway message of the entire thesis.



## Chapter II: Background

### **Grounding the Research in Geography and Related Disciplines**

#### Geography

This thesis fits in the subfield of cultural biogeography, which involves understanding natural landscapes before and during human alteration. For instance, later in this chapter, a section focuses on what bighorn population dynamics were like before, during, and after Euro-American settlement of their habitats' landscapes. Additionally, cultural biogeography involves studying culturally modified landscapes (Gaile and Willmott 2003). Any bighorn disease outbreak location that hosted domestic sheep is a culturally modified landscape, and this study profiles six of these.

This thesis also strongly relates to the biogeographic subfield of nature conservation. According to Gaile and Willmott, "a unifying theme of nature conservation studies is the importance of understanding the role of people in changing patterns in nature" (2003, 22). This study provides a better understanding of the role of people in the changing patterns of bighorn disease caused by domestic sheep. By geographically examining bighorn disease trends, an objective is to gain insights that will help prevent future outbreaks and thus conserve bighorns. Concern for bighorn conservation is a major driving force behind this project.

In addition to fitting well within the discipline of geography, this study fills a gap in geography literature. Separate searches for "bighorn sheep," "livestock policy," and "wildlife disease" in the database for issues of *The Professional Geographer* published from 1984-2010 resulted in zero matches. Identical searches in *The Annals of the Association of American Geographers* database (covering 1911-2011) resulted in a

similar lack of matches. A search for “wildlife management” in both journals brought up only a few articles—all not closely related to this project’s topic. One geography book (*Animal Spaces, Beastly Places . . .*) addresses human-wildlife interaction but does not examine the questions this project asks (Philo and Wilbert 2000). Thus, a geographic literature gap exists that this project fills.

### Wildlife Management

In the “Management Theory” chapter of his landmark 1933 text, *Game Management*, renowned conservationist Aldo Leopold defined such management as “the art of making land produce sustained annual crops of wild game for recreational use” (1986, 3). For decades, wildlife management was synonymous with game management, but it is now more inclusive of non-game species and broader ecological considerations (Sinclair, Fryxell, and Caughley 2006; Bolen and Williamson 2003). As a large hoofed mammal, bighorns have long been managed as game.

According to Sinclair, Fryxell, and Caughley: “‘Wildlife management’ may be defined for present purposes as ‘the management of wildlife populations in the context of the ecosystem’” (2006, 2). They emphasize that “the core around which [wildlife] management objectives are organized” is “the manipulation or protection of a population to achieve a goal” (2006, 2). In addition to being geographic, this study fits in the discipline of wildlife management because it focuses on policies implemented to protect wildlife populations. All interaction management policies analyzed in this study were formulated with the goal of protecting bighorns.

Wildlife management can be manipulative or custodial (Sinclair, Fryxell, and Caughley 2006). This study focuses on both forms of management as they pertain to

bighorns. However, because of bighorns' delicate status and disease problems, they often receive manipulative management. Sinclair, Fryxell, and Caughley explain that:

Manipulative management does something to a population, either changing its numbers by direct means or influencing numbers by the indirect means of altering food supply, habitat, density of predators, or prevalence of disease. Manipulative management is appropriate when a population is to be harvested, or when it slides to an unacceptably low density, or when it increases to an unacceptably high level. (2006, 3)

Wildlife managers have long used manipulative management on bighorns. One of the best examples is the species expansion strategy of capturing bighorns and relocating them to new, vacant habitat. Bighorn transplanting has been a common management tool for decades (Toweill and Geist 1999) and is further discussed later in this chapter. As the "Results" chapter of this study demonstrates, it is important for managers to carefully consider domestic sheep presence in a region before making it a new home for bighorns. In addition to translocations, this thesis addresses the manipulative management practice of killing bighorns that get close enough to domestic sheep to pose a disease risk.

Sinclair, Fryxell, and Caughley contrast manipulative management with custodial management, which they define as "preventative or protective. It is aimed at minimizing external influences on the population and its habitat" (2006, 3). Much of this project's policy analysis criteria focus on custodial management. For example, various policies related to controlling domestic sheep (buffer zones, trailing restrictions, supervision rules, education, etc.) are preventative and demonstrate custodial management of bighorns.

Valdez and Krausman state: "Relative to other North American ungulates, management of bighorn sheep . . . is in its infancy. Bighorn management has progressed rapidly since 1975, and enough good and bad experience has accrued to assist in selecting management guidelines" (1999, 238). This study compiles existing guidelines, and could

serve as a valuable tool for enhancing decision-making and maturing bighorn management past its infancy.

According to Sinclair, Fryxell, and Caughley, in the process of wildlife managers' decision-making:

Social, political, biological, and economic considerations are each examined and given due weight. Some people are good at this and others less so. In all cases, however, there is a real advantage, both to those making the final decision and to those tendering advice, to have the steps of reasoning laid out before them as a decision is approached. (2006, 4)

Later in this chapter, social, political, and biological considerations as they pertain to bighorn-domestic sheep management are addressed. Sinclair, Fryxell, and Caughley add that “with more complex problems it helps to be more formal and organized, mapping out on paper the path to the decision through the facts, influences, and values that shape it. That process should be explicit and systematic” (2006, 4). This thesis highly reflects these principles of wildlife management theory. It tackles the complex problem of bighorn-domestic sheep disease in an organized, systematic fashion that leads to a decision in Chapter VI.

#### *Wild-Domestic Sheep Management*

Through the years, wild-domestic sheep management has become its own subdiscipline that involves trying to balance the needs of wildlife and livestock producers. Clifford et al. stated that “the challenge of balancing species conservation and livestock-based livelihoods is exemplified by the respiratory disease complex affecting North American bighorn sheep. . .” (2009, 2559). This study directly addresses the challenge of that attempted balance and fills literature gaps in the process. Much of the information on bighorn-domestic sheep disease transmission and management concerns

is temporally and topically spread through numerous publications and largely focuses on biology rather than policy. This project focuses on the spatial dynamics of both, emphasizing policy and some policy-related biology. Nonetheless, similar peer-reviewed literature on wild-domestic domestic sheep interaction policies does exist.

Monello, Murray, and Cassirer published an article in the *Canadian Journal of Zoology* focusing on the distribution and ecology of bighorn pneumonia outbreaks. Their focus on the characteristics of areas that experienced bighorn disease outbreaks reflects the case study location profile aspect of this thesis. However, unlike this project, the researchers did not emphasize the influence of policy (2001). They “evaluated the relationship between pneumonia-induced dieoffs in bighorn sheep and environmental and biological factors by analyzing demographic information for 99 herds across the species’ geographic range” (Monello, Murray, and Cassirer 2001, 1423).

The researchers discovered that most die-offs happened near times of peak population, which indicates factors like stress and decreased food supply may have made them more susceptible to disease (Monello, Murray, and Cassirer 2001). Nonetheless, they also remarked: “Our results suggest that bighorn sheep herds are rendered vulnerable to pneumonia principally through density-dependent factors, as well as through horizontal transmission of *Pasteurella* spp. from domestic sheep serving as reservoir hosts” (2001, 1423).

In part of an environmental impact statement for the Payette National Forest, Tim Schommer (National Bighorn Sheep Biologist for the USFS) discusses bighorn-domestic sheep best management practices (Appendix E), which he describes as “on-the-ground practices that reduce the risk of contact between domestic sheep and bighorn sheep where

bighorn sheep exist” (USFS 2010b, 1). In this thesis, such practices are generally referred to as interaction policies. Schommer analyzed the efficacy of such policies in the context of his personal experience. In reference to these practices, Schommer states: “To my knowledge, no peer reviewed literature exists that evaluates the effectiveness of these grazing practices for reducing the risk of contact between the two species” (USFS 2010b, 1).

However, a significant amount of literature has recently been published analyzing wild-domestic sheep interaction policy as it pertains to endangered Sierra Nevada bighorn sheep. In 2006, the California Department of Fish and Game (CDFG) published a report covering the efficacy of management practices focused on domestic sheep interaction with Sierra bighorns. This study had limited scope and focused on interaction policies covering bighorns in one part of the Sierra from July to October 2005 (CDFG 2006). The CDFG emphasized the importance of location in determining policy efficacy. Though no interaction occurred during the study, the CDFG stated: “Factors such as the elevation grazed, the density of vegetation used by domestic sheep, the level of predation, and domestic sheep oversight by herders and guard dogs were such that risk of contact was minimized insufficiently given proximity to occupied bighorn sheep habitat” (2006, 1).

Sierra bighorns received additional attention with Clifford et al.’s 2009 *Biological Conservation* article entitled: “Assessing disease risk at the wildlife-livestock interface: A study of Sierra Nevada bighorn sheep.” In this study, researchers “constructed a model to assess how different management strategies (grazing allotment closures, grazing time reductions, and reduced probability of stray domestic sheep) affect the risk of . . . disease

transmission from domestic sheep to endangered Sierra Nevada bighorn sheep. . .” (2009, 2559). Clifford et al. concluded that bighorns and domestic sheep are definitely not compatible on the same ranges (2009).

A similar study focusing on Sierra bighorns was published by Cahn et al. in a 2011 issue of *The Journal of Wildlife Management*. In that study, researchers “sought to heuristically evaluate the efficacy of management strategies aimed at reducing disease risk to or impact on modeled bighorn populations” (Cahn et al. 2011, 1753). Three populations were modeled based on 1980-2007 data. Researchers concluded their article by recommending the continuation of “restricted grazing regimes and stray management to ensure recovery [of Sierra bighorns]” (Cahn et al. 2011, 1753). They also remarked: “Managing bighorn and domestic sheep for geographic separation until Sierra Nevada bighorn sheep achieve recovery objectives would enhance the likelihood of population recovery” (Cahn et al. 2011, 1753).

In contrast to the 2006 CDFG study on Sierra bighorns, this study has a wider timeframe spanning 1990-2010. Unlike all the Sierra bighorn studies discussed above, it also focuses on multiple bighorn subspecies. Moreover, this project distinguishes itself from similar policy analyses by using a case study approach with a wide geographic scope spanning multiple states.

With its hefty agglomeration of disease policy data and its wide scope, this thesis could be used as a resource to help prevent bighorn disease outbreaks and enhance management recommendations. Nonetheless, the Wild Sheep Working Group (WSWG) of the Western Association of Fish and Wildlife Agencies (WAFWA) released a detailed set of “Recommendations for Domestic Sheep and Goat Management in Wild Sheep

Habitat” (2007, 2010b, 2012). These policy suggestions are comprehensive and well-researched by wildlife professionals, so it is doubtful this project could generate recommendations that are substantially new or more effective than those established by WAFWA. However, this study’s main aim is to gain insights from the past to shed light on policy efficacy.

## **Bighorn Ranges and Subspecies**

### *Introduction*

An assortment of wild sheep inhabit North America. Analyzing their geographic ranges and taxonomy provides a better understanding of bighorn-domestic sheep interaction policies. Not all North American wild sheep are the same. Different populations receive different levels of protection and face different challenges regarding domestic sheep. For example, thinhorns are more abundant and heavily hunted than bighorns (Toweill and Geist 1999). Additionally, some bighorn populations receive federal endangered species protection, which has caused managers to pay special attention to the domestic sheep threat in particular areas (USFWS 2000, 2007).

Thinhorns (*Ovis dalli*) are the most plentiful variety of North American wild sheep. They live in large swaths of contiguous mountain habitat in Alaska and northwest Canada (Toweill and Geist 1999). Thinhorns include the white Dall’s sheep (*O. d. dalli*) and the Stone’s sheep (*O. d. stonei*), which possesses coloration encompassing shades of gray and dark brown with patches of white (Toweill and Geist 1999; Valdez and Krausman 1999). Thinhorns live far from widespread domestic sheep grazing, and they do not experience the periodic disease outbreaks that regularly afflict their bighorn relatives (WAFWA 2007).





Figure 2.1. Dall's sheep ram. Photograph by National Park Service (NPS 2012c).

In the western U.S., bighorns inhabit mountains, rimrock, canyons, and badlands. Compared to thinhorns, bighorns live in more reduced, scattered, and isolated populations (Toweill and Geist 1999). According to Valdez and Krausman: “Dall’s and Stone’s sheep populations have remained relatively unimpacted by humans and have retained their historical distribution and numbers. [Bighorn] populations of southwestern Canada, the western United States, and northern Mexico have declined due to human impacts” (1999, 19).

Through the decades, bighorn taxonomy has not been consistent. Wehausen and Ramey II state: “The long-accepted taxonomy of bighorn sheep [was] based on comparisons of skull measurements [made] by Cowan (1940) [who] separated bighorn sheep into 3 northern and 4 desert subspecies” (2000, 145). Nonetheless, Cowan’s work involved small samples and “violation of statistical assumptions” (Wehausen and Ramey

II 2000, 145). At present, biologists generally recognize five bighorn subspecies (Toweill and Geist 1999; USFWS 2007).

Taxonomy is an important component of bighorn conservation and management because it can define management policies and determine levels of protection and funding (Ramey 1993). According to Wehausen and Ramey II:

Conservation is dependent upon accurate information on patterns of genetic variation in the natural world and evolutionary processes that brought about those patterns of variation. However, much of past taxonomy at or below the species level is antiquated because it lacks an adequate quantitative basis and reflects an archaic typological view of species and subspecies not consistent with an evolutionary perspective. (2000, 157)

The following profiles address general differences between bighorn varieties and touch on how bighorn taxonomy has evolved beyond archaic methodologies.

#### Audubon's

In historic times, the now-extinct Audubon's bighorn (*O. c. auduboni*) lived in the badlands and river canyons of the Dakotas, Montana, Nebraska, and Wyoming (Valdez and Krausman 1999; Toweill and Geist 1999). Euro-American settlement caused the extinction of the Audubon's bighorn. For years, it has been lamented as a lost subspecies. However, after more completely examining Audubon's bighorn skulls, biologists now believe the sheep were not significantly different from bighorns living in the Rockies and never deserved separate subspecies classification (French 2004; Wehausen and Ramey II 2000). In addition to biology, geography helps explain this taxonomic revision.

Wehausen and Ramey II remark:

It is difficult to imagine any biogeographic barriers that would have separated Audubon and Rocky Mountain bighorn sheep, especially given that during periods of Pleistocene glacial advance, most of the foothills of the Rocky Mountains and plains to the east were open steppe habitat conducive to bighorn sheep dispersal. (2000, 154-155)



Figure 2.2. Bighorn habitat in the North Dakota badlands. Photograph by author.

### Rocky Mountain

Rocky Mountain bighorns (*O. c. canadensis*) are the largest, most abundant bighorn subspecies (Valdez and Krausman 1999; Gildart 1997). They live throughout the Rockies from Alberta and British Columbia down to Arizona and New Mexico. Rocky Mountain bighorn rams have thicker and tighter-curling horns compared to other bighorn subspecies (Toweill and Geist 1999). As Wehausen and Ramey II emphasize, the classification of Rocky Mountain bighorns has remained consistent:

We found little morphometric variation within the Rocky Mountains, most of which involved differences between Colorado and the northern Rocky Mountains. Similarly, Luikart and Allendorf (1996) found no evidence of long-term population isolation or differentiation within the Rocky Mountains from mtDNA markers and suggested that the Rocky Mountains have lacked subdivision by long-term biogeographic barriers. Even during periods of glacial advance, much of the Rocky Mountains supported open steppe habitat that would have favored gene flow among populations. (2000, 157)





Figure 2.3. Rocky Mountain bighorns in Colorado. Photograph by author.

### California

California bighorns (*O. c. californiana*) roam arid rimrock, mountain, and canyon country that stretches from the northern Great Basin to other high desert regions between the Cascades and Rockies (Toweill and Geist 1999). Confirmed populations of California bighorns no longer live in California, though they used to inhabit the northeastern part of the state (Epps et al. 2003). However, according to Epps et al.: “Anecdotal reports [and the presence of a young ram in the Warner Mountains] have suggested that bighorn sheep may be appearing again in northeastern California” (2003, 25). California bighorns are unique in that Euro-American settlement completely extirpated them from the western U.S. Current populations in the U.S. were all derived from stock that originally came from British Columbia starting in 1954 with a transplant to Oregon’s Hart Mountain National Antelope Refuge (Toweill and Geist 1999).



Figure 2.4. Southern Oregon's Hart Mountain provides quality California bighorn habitat. Photograph by author.

Biologists have considered California bighorns a distinct subspecies for decades, partly because of skull measurement comparisons published by Cowan in 1940. However, that classification is rocky because, after Wehausen and Ramey II carried out thorough univariate and multivariate statistical analyses of skulls and horns, they determined that California bighorns from British Columbia (progenitors of the only California bighorns left on the continent) were actually Rocky Mountain bighorns. Moreover, mitochondrial DNA analysis of British Columbia California bighorns supports this reclassification because it shows them to have the same haplotype as Rocky Mountain bighorns to the east (Wehausen and Ramey II 2000).

Wehausen and Ramey II also classified extinct California bighorns from Washington as Rocky Mountain bighorns (2000). However, interestingly, the researchers assigned:

. . . the extinct native populations of *O. c. californiana* from Oregon, southwestern Idaho, northern Nevada, and northeastern California to the Great Basin Desert form of *O. c. nelsoni* [a type of desert bighorn], recognizing that some transition to Rocky Mountain bighorn sheep probably occurred along that northern boundary. (Wehausen and Ramey II 2000, 145)

Despite being the same species, California bighorns usually look slightly different (leaner, wider-flaring horns on rams) than bighorns in the Rockies. Wehausen and Ramey II explain this:

We suggest that the perceived tendency to smaller horn size among male bighorn sheep west of the Rocky Mountains in British Columbia may reflect environmental, rather than genetic variation. Bighorn sheep in this region live mostly along low-elevation river breaks, are largely nonmigratory, and therefore, do not have nutritional benefits of seasonal elevational migration and alpine forage. (2000, 155)

In the remainder of this paper, California bighorns will continue to be referred to as such because that is still largely the convention in wildlife biology and has been for some time. Additionally, bighorns classified as *O.c. californiana* typically live in different habitat types than Rocky Mountain bighorns, which validates treating them separately for the sake of landscape representation.

### Desert

Desert bighorns inhabit the southwestern U.S., northern Mexico, and the Baja Peninsula. Compared to other bighorns, desert bighorns are leaner and have reduced hair insulation (Toweill and Geist 1999). Based on skeletal measurements and coloration, biologists have generally recognized four varieties of desert bighorns: Nelson's (*O. c. nelsoni*), Mexican (*O. c. mexicana*), Peninsular (*O. c. cremnobates*), and Weem's (*O. c. weemsi*) (Toweill and Geist 1999). However, mitochondrial DNA analysis does not support recognizing multiple varieties of desert bighorns and suggests they are all one subspecies (Ramey II 1995).



Generally, “desert bighorns are treated as a single group” (Toweill and Geist 1999, 158). *O.c. nelsoni* is the scientific desert bighorn name that remains when invalid subspecies are eliminated (Wehausen and Ramey II 2000). Nonetheless, desert bighorns are not necessarily homologous. Wehausen and Ramey II note that “considerable cranial morphometric variation was found within *O. c. nelsoni*, and bighorn sheep from the desert regions appeared to have general north–south differentiation into 2 basic forms, hot (Mohave, Sonoran, and Chihuahuan) desert sheep and cold (Great Basin) desert sheep” (2000, 146).



Figure 2.5. Desert bighorn ram navigates through agave. Photograph by Tim Glenner (CDFG 2010).

In 1998, a population of desert bighorns in southern California’s Peninsular Ranges (extending from the San Jacinto Mountains down to Mexico) (USFWS 2000) was “listed as endangered under the distinct vertebrate population provision of the Endangered Species Act” (Epps et al. 2003, 30, 34). Peninsular bighorns were listed even

after they were “no longer considered a valid subspecies” (Epps et al. 2003, 30).

However, these listed bighorns were officially reclassified in 2009 as a distinct population segment of the Nelson’s desert bighorn (USFWS 2011).

### Sierra Nevada

Sierra Nevada bighorn sheep (*O. c. sierrae*) live in the central and southern Sierra Nevada Mountains of eastern California. Once classified as California bighorns, biologists have since recognized bighorns in the Sierra as a unique subspecies based on skull examinations and genetics (USFWS 2007). Mitochondrial DNA analysis has revealed that Sierra bighorns possess a unique haplotype (Wehausen and Ramey II 2000). These bighorns are more closely related to desert bighorns than Rocky Mountain bighorns (Toweill and Geist 1999). Sierra rams also have very wide-flaring horns with relatively little curl (CDFG 2011b).



Figure 2.6. Sierra Nevada bighorn rams at Wheeler Crest. Photograph by California Department of Fish and Game (CDFG 2011c).



In the 1990s, bighorns in the Sierra Nevada suffered severe population declines caused by mountain lion (*Puma concolor*) predation and harsh weather. In 2000, they gained federal endangered status as a distinct population segment of California bighorns (USFWS 2007). However, in 2008, Sierra bighorns were officially reclassified as their own valid subspecies (DOI 2008).

## **History of Bighorn Population Dynamics**

### Introduction

By exploring bighorns' historical population dynamics, one can better understand how much is at stake with the risk of bighorn-domestic sheep disease transmission. “[Bighorns] have made the transition from relative abundance to one of the rarest ungulates in North America” (Valdez and Krausman 1999, 19-21). Toweill and Geist elaborate on bighorns' former population numbers:

Bighorn sheep were remarkably abundant in the early nineteenth century; Thomas Seton estimated that there may have been up to two million bighorn sheep in North America around 1800. Although this estimate was likely high, many scientists who have examined archaeological evidence and reviewed accounts left by explorers believe that bighorn sheep may well have been the most common big game animal in mountainous regions. (1999, 67)

Some of the most striking evidence of past bighorn distributions exists “in the form of pictographs (images painted on a rock surface) and petroglyphs (images physically pecked or hammered into the surface of rock faces) [made by American Indians]” (Toweill and Geist 1999, 4). Bighorns are portrayed via rock art in northwestern Mexico and every state in the western U.S. (Toweill and Geist 1999).

According to Toweill and Geist:

A survey of sites featuring bighorns in rock art was done by Campbell Grant in 1980; he found that the greatest concentrations of sites are found in southern California's Coso Range, the ‘four corners’ area (where Utah, Arizona, New

Mexico, and Colorado converge), south-central Oregon, and the Columbia River Gorge along the Washington-Oregon border. In the Coso Mountain Range alone, over 100,000 petroglyphs have been discovered, and just over half depict wild sheep. (1999, 4)

In some of these regions, bighorn distributions substantially shrank because of a new threat: Euro-American settlement. This wave of migration and natural resource exploitation caused a precipitous decline of bighorn populations, but from the mid-twentieth century to current times, wildlife managers have worked hard to restore the wild sheep of the western U.S. (Toweill and Geist 1999).



Figure 2.7. Desert bighorn petroglyphs near Coso Junction, CA. Photograph by author.

### Devastation

In the 1800s and early 1900s, bighorn numbers in the continental U.S. dramatically declined. Unregulated hunting was one of the most direct causes (Valdez and Krausman 1999). People killed bighorns for food, trophies, and the wild game market (ODFW 2003). Other contributors to their decline included habitat loss, alteration, and

disturbance from human land use. Some of the most significant bighorn decline factors related to livestock: cattle and domestic sheep damaged habitat through overgrazing. In the early 1800s, cattle and sheep heavily grazed northwest Mexico and the southwest U.S. In the late 1800s and early 1900s, livestock overgrazed significant portions of the northwest U.S. (Valdez and Krausman 1999).

In addition to habitat degradation, livestock disease (especially from domestic sheep) was particularly devastating to bighorns (Toweill and Geist 1999). With Western settlement, shepherds herded domestic sheep over vast stretches of bighorn habitat (ODFW 2003). For example, by 1820, an estimated 3,000,000 domestic sheep grazed in central and northern New Mexico (Toweill and Geist 1999). Another example: from 1911-1920, more than 10,000 domestic sheep grazed the Standley Allotment in northeast Oregon's Wallowa Mountains (Coggins 2010).

Although a great deal of death-causing encounters between wild and domestic sheep transpired in the 1800s, in the Southwest, initial interaction probably happened centuries earlier. Spanish conquistador Francisco Vázquez de Coronado searched for the fabled Seven Cities of Cibola on a 1540 expedition that included hundreds of domestic sheep and spanned Mexico, Arizona, New Mexico, and Texas. On this expedition, he reported seeing bighorns (Toweill and Geist 1999; Simms 2006; Fish 1998), so interaction as early as the 1500s seems likely. In 1598, don Juan de Oñate brought thousands of domestic sheep (in addition to goats and cattle) "to the pueblos along the Rio Grande and Rio Chama in northern New Mexico" (Weisiger 2009, 63). By around 1700, Spanish soldiers started reporting significant numbers of domestic sheep using the valleys and mesas of Navajo Indian territory (Weisiger 2009).

In the American Southwest, domestic sheep pastoralism and transhumance became such an important part of the Navajo's cultural fabric that some tribesmen claimed the Navajo had lived with herds of domestic sheep "since time immemorial" (Weisiger 2009, 63). Thus, despite what some of the traditional bighorn history narratives imply, domestic sheep grazing in bighorn habitat was not solely caused and promoted by Euro-American settlers. Though domestic sheep have been valuable to the Navajo, in modern times, desert bighorn hunting has become a significant economic activity on tribal land and is actively promoted (Navajo Big Game Adventures 2010).



Figure 2.8. Domestic sheep in Utah, 1940. Photograph by Bureau of Land Management (BLM 2009).

All bighorn subspecies sharply declined because of Euro-American settlement. Rocky Mountain bighorns were extirpated from New Mexico by 1902, Washington by 1917, Oregon by 1945, and Nevada by 1946. Utah likely had fewer than 100 Rocky Mountain bighorns by the mid-1930s. In the continental U.S., California bighorns were

completely wiped out. They were extirpated from California by about 1913, Oregon by 1917, Washington by 1925, and Idaho and Nevada by 1940. Only two populations of desert bighorns persisted in New Mexico by 1955. The last sighting of native desert bighorns in Texas occurred in 1960. Only one viable population of desert bighorns survived in Utah by the mid-1960s (Toweill and Geist 1999). By the 1970s, Sierra bighorns lived in only two populations that together totaled about 250 animals. Bighorns in the Sierra reached a low point of about 100 animals in 1995 (USFWS 2007).

The Desert Bighorn Council's (DBC) technical staff summarizes why bighorn decline was especially damaging compared to that experienced by other big game animals:

Following enormous population declines in the late 1800s and early 1900s, bighorn populations did not recover, in contrast to other wildlife species such as mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*). Bighorns have demonstrated much less tolerance than other native North American ungulates to poor range conditions, interspecific competition, overhunting, and stress caused by loss of habitat. Furthermore, they have shown a much greater susceptibility to diseases. (1990, 33)

### Restoration

Efforts to protect bighorns began with hunting regulations instituted in the 1800s. For example, in 1861, Nevada prohibited bighorn hunting from January to July (NDOW 2001). In 1872, Montana passed its first hunting regulation affecting bighorns (a season limitation), and in 1895, the state "specified a bag limit of 8 sheep" (MFWP 2010a, 12). In 1878, California passed legislation protecting all its bighorns from hunting (USFWS 2007). Oregon protected its bighorns from hunting in 1911 (ODFW 2003).

The government also reserved habitat for bighorns (ODFW 2003; NDOW 2001). For example, in 1915, the Steens Mountain Game Refuge was established in Oregon to



protect California bighorns (ODFW 2003). Also, in 1936, the U.S. Fish and Wildlife Service created the Desert National Wildlife Refuge in Nevada to protect desert bighorns (NDOW 2001).

Thanks to efforts initiated largely in the 1960s, wildlife managers have restored bighorns to many former ranges (Figure 2.10). Restoration was carried out through trapping/transplanting actions, habitat management, installation of water sources, and biological research. Rocky Mountain and California bighorns have been established in former Audubon's bighorn habitat. Rocky Mountain and desert bighorns' ranges have also been expanded. Additionally, managers have largely restored California bighorns to the U.S. with transplants from British Columbia (Toweill and Geist 1999). Furthermore, Sierra bighorns had increased to about 400 animals by 2011 (CDFG 2011a).



Figure 2.9. Bighorn reintroduction release in Idaho. Photograph by Bureau of Land Management (BLM 2009).

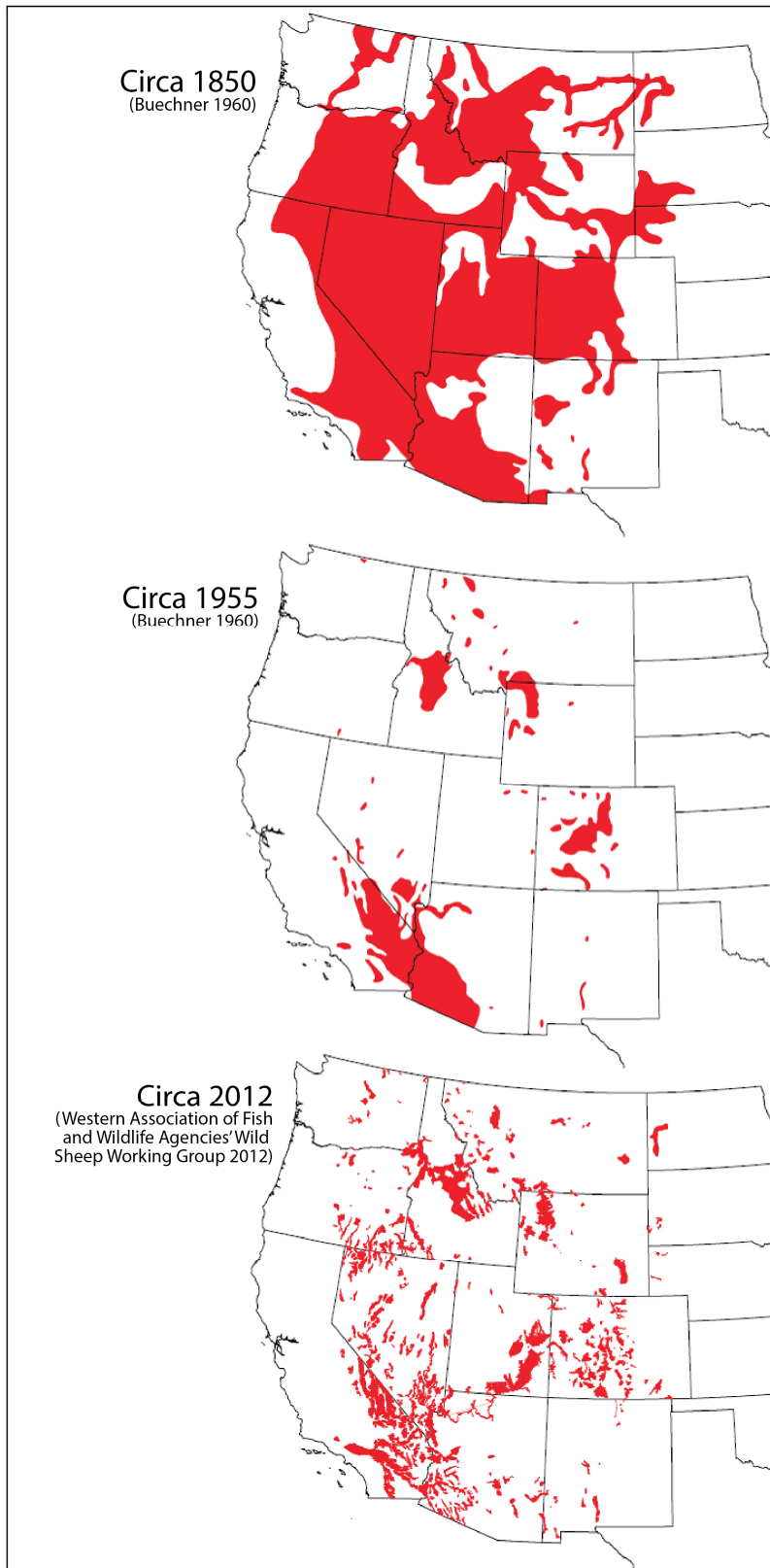


Figure 2.10. Bighorn range reduction and expansion: 1850-2012 (Texas data are excluded). *Source:* WSF 2012c. Use permission granted by Hurley 2012.

Regarding North American wild sheep in general, Toweill and Geist state: “Even though there have been many failures and setbacks, herds have grown dramatically” (1999, 198). About 15,000-18,000 bighorns lived in the western U.S. in 1960, but by 2011, the number of bighorns had grown to about 70,000 (Buechner 1960; WSF and WAFWA 2013). In 2010, roughly 90,000-114,000 thinhorn sheep inhabited northwest Canada and Alaska. A total of about 160,000-180,000 wild sheep ranged across western North America in 2010 (WSF and WAFWA 2013). While these numbers may seem large to a casual reader, they actually highlight the scarcity of wild sheep relative to other big game in the American West. For example, in 2009, an estimated 3.8 million mule deer (including black-tailed deer) lived in North America. Elk are less abundant than mule deer in the West, but their numbers also far surpass those of bighorns. In 2009, western North America hosted approximately 1.1 million elk (Walker 2011).

More organized advocacy for bighorns (especially from hunters) and efforts to separate bighorns from domestic sheep have contributed to ongoing restoration (Toweill and Geist 1999). However, by 2006, bighorn numbers were thought to be less than 10 percent of numbers that existed prior to Euro-American settlement. The majority of existing herds resulted from transplants, and most bighorn populations were also isolated, small, and contained fewer than 100 animals (USFS 2006).

## **Bighorns’ Importance**

### *Introduction*

Compared to other wildlife species, bighorns have special importance. Their unique, valuable status supports the necessity to prevent their premature death by disease. Bighorns are ecologically important because of their fragility (Valdez and Krausman



1999). They are also economically important because of the value hunters and wildlife viewers place on them (ODFW 2003). Additionally, they are aesthetically important because people often harbor positive emotions toward them (NDOW 2001; Harris and Shaw 2002). Lastly, bighorns have intrinsic value. Valdez and Krausman emphasize that bighorns have a rightful share of North American wilderness that they must be allowed to inhabit (1999).

### Ecologic

A major reason bighorns are ecologically important is because they are rare and vulnerable (Valdez and Krausman 1999). According to Valdez and Krausman, “wild sheep face a precarious future. They are an ecologically fragile species, adapted to limited habitats that are increasingly fragmented” (1999, 22). Bighorns are limited to habitat islands with steep, rugged escape terrain and open country that allows them to spot predators (Valdez and Krausman 1999). Additionally, special behavior patterns constrain bighorns’ adaptability (Toweill and Geist 1999). Toweill and Geist summarize these behaviors:

Wild sheep are habitat specialists, animals with a high level of home range fidelity. They not only do not disperse well or easily across the landscape, but populations depend—for their very existence—on transmittal of learned behaviors through successive generations. This kind of behavior, useful in a species which has adapted to a landscape that changes on the order of centuries, can be critically limiting to a population subject to large or wide-scale population losses, the sort of losses associated with disease outbreaks. In these situations, large-scale die-offs have become an all-too-familiar pattern to wildlife managers. (1999, 198)

According to Toweill and Geist: “Devastating die-offs can quickly undo the success of years of restoration efforts. Bighorn sheep in particular . . . are notoriously susceptible to a variety of disease organisms that affect domestic sheep little if [at] all” (1999, 202). Bighorns are also ecologically sensitive because they have low reproduction

rates. Most populations grow slowly compared to other big game animals. Lamb mortality is also often high (Toweill and Geist 1999).

### Economic

Bighorns often mean big money, which is a big reason unnecessary loss to livestock pathogens is a big problem. Bighorn hunting can bring tremendous economic revenue to state governments and wildlife management agencies (Heimer 2000).

Bighorns also generate money through nonconsumptive uses (ODFW 2003; Cummings and Stevenson 1996).

One of the clearest indicators of bighorns' economic importance is the value hunters place on them. According to Erickson: "Bighorns have long been a highly prized trophy by sportsmen. This is as much related to the bighorn's massive horns and rareness as it is to the difficulty for a hunter to obtain a license" (1988, 47). Bighorns are popular and novel quarry that provide once-in-a-lifetime hunting opportunities. For example, in Oregon, a person can only have one controlled bighorn hunting permit in their lifetime (ODFW 2003). Bighorn hunting in Arizona also occurs on a once-in-a-lifetime basis (AZGFD 2012).

In 2011, one resident Montana hunter drew a bighorn tag after applying for over 20 years. For the 2011 season, 16,704 Montanans applied for 118 ram permits, putting their chance of success below 1 percent. Nonresidents' odds were more challenging: 6,626 of them applied for nine tags (French 2011). Furthermore, just the application fee for hunting bighorns can be pricy. For example, in 2011, nonresident applicants who drew a bighorn hunting permit in Montana had to pay a \$755 fee (MFWP 2011).



Figure 2.11. Many hunters prize bighorn rams' massive horns. Photograph by Tim Glenner (CDFG 2010)

In addition to paying for the privilege to hunt bighorns, hunters spend money during their hunts. Using 1991 dollar values, an Oregon Department of Fish and Wildlife survey estimated a bighorn hunter spends \$1,164 (\$1,968.03 in 2013 dollars) per trip on variable costs that do not include license fees (ODFW 2003; USDL 2013). With 2000 dollar values, a Nevada Department of Wildlife (NDOW) study determined a resident bighorn hunter spent \$2,924 (\$3,910.21 in 2013 dollars) per hunt with non-resident hunters spending \$10,077 (\$13,475.79 in 2013 dollars) per hunt (NDOW 2001; USDL 2013).

Auctioning bighorn hunting tags has raised hundreds of thousands of dollars for wildlife management and conservation. For example, in 2011, continental U.S. bighorn permits auctioned by the Wild Sheep Foundation (WSF) ranged in price from \$72,500 (Utah permit) to \$290,000 (Montana permit) (WSF 2011a). At the 2013 WSF convention,

a Montana bighorn tag sold for a record \$480,000, breaking the previous record of \$405,000 set by an Alberta bighorn tag in 1999 (WSF 2013).

The WSF sells some hunts donated by outfitters and guides. Revenue from donated hunts can go directly toward bighorn management and research grants, though some money may be used for administration and to cover donor expenses. However, WSF has generated the most money by selling Governor's permits (Heimer 2000). Starting with Utah in 1980, states in the western U.S. began to annually auction at least one bighorn permit. These permits often provided buyers with special privileges (Erickson 1988). For example, the Wyoming Governor's bighorn license for 2011 allowed its purchaser to hunt in multiple zones (WSF 2012b). Although 90 percent of Governor's permit money has usually gone back to state agencies with the idea it would be used for bighorn management, this has not always been the case (Heimer 2000).

In addition to expensive, competitive hunting permits, bighorns' high consumptive economic value is reflected by the fact that some states have special regulations for possession of bighorn horns (MFWP 2012; WGFD 2013). For example, according to the Montana Department of Fish, Wildlife, and Parks (MFWP): "Bighorn ram horns greater than one-half curl must be plugged or pinned at any Fish, Wildlife & Parks office within 10 days after harvest" (2012, 32). The MFWP adds: "It is illegal to possess a bighorn sheep head picked up in the wild" (2012, 32).

People like bighorns enough to spend money on non-hunting activities related to them (ODFW 2003). One specific example of bighorns with nonconsumptive economic value relates to a 1995 desert bighorn transplanting effort in Nevada. Cummings and Stevenson explain:

The capture operation in the River Mountains was temporarily halted following a complaint to the governor's office by a golf course and community developer. The protest centered upon the removal of sheep that were routinely observed on the periphery of the developing Lake Las Vegas Community and [thus, the protest also centered on] the loss of an extraordinary and unprecedented marketing advantage [provided by the nearby bighorns]. (1996, 41)

The Bureau of Land Management (BLM) provides an example of bighorns' demonstrating measurable economic value in Colorado. The BLM states:

Several viewing areas have been constructed throughout the West for the public to see these animals. For example, the bighorn sheep viewing area near Georgetown, Colorado, had over 32,000 visitors during the first 11 months of operation. The coin-operated telescopes at the facility generated \$8,000 during the same 11-month period. (BLM 1995, 8)



Figure 2.12. Colorado's Georgetown bighorn sheep viewing area. Photograph by author.

The National Bighorn Sheep Interpretive Center—located in Dubois near the foothills of Wyoming's Wind River Mountains—is another example of bighorns demonstrating easily measurable nonconsumptive economic value (NBSIC 2012b). In its

first 19 months of operation, the Center hosted over 23,000 people (BLM 1995b). The Center is focused on educating the public about bighorns and encouraging conservation (NBSIC 2012a). However, Center operators charge admission to view their exhibits and offer wildlife viewing tours (at \$50 per person) featuring bighorns (NBSIC 2012a, b).

### *Aesthetic*

Many people appreciate bighorns for their aesthetic value. The NDOW illustrates this by stating: “The sight of bighorn sheep leaping nimbly across rugged slopes elicits emotions that impress and inspire viewers. From primitive inhabitants to civilized peoples, a recurring theme in records kept on bighorn sheep is the strong sentiment elicited by this animal” (2001, 4). Valdez and Krausman aptly summarize the glamorous mystique and appeal of North American wild sheep by remarking:

Mountain sheep . . . are one of the most striking large mammals in North America. Simply observing them is an exciting and gratifying aesthetic experience. Mountain sheep epitomize wilderness. They occupy some of the most inaccessible, rugged, and spectacular habitats in North America. Their ability to negotiate precipitous terrain is legendary. (1999, 3)

Much of the public considers bighorns important. For example, bighorns are the official state mammal in Nevada and Colorado (BLM 1995b). The Colorado Division of Wildlife (CDOW) remarks that bighorns “are among the most sought after watchable wildlife species in the state” (2009, 1).

Additional evidence for positive public attitudes comes from a study gauging Tucson residents’ perceptions of bighorns that lived near them in the Pusch Ridge Wilderness of Arizona (Harris and Shaw 1993). Of 184 surveys completed by homeowners, Harris and Shaw said that “the majority (>66%) of the homeowners were willing to give up their activities within [the Wilderness] for the long term survival of the



sheep population” (1993, 18). Additionally, regarding a survey measuring public attitudes toward Peninsular bighorns in California, McNeil et al. note:

The overwhelming majority [of respondents] stated that bighorn conservation efforts would either not impact their lives or [would] impact their lives in a positive way. These respondents supported conservation in general . . . , stated that sheep have aesthetic values, and hope that future generations will be able to enjoy the sheep. (2002, 8)

Bighorns also have especially high value to the public in Montana. According to MFWP: “Bighorn sheep are a special wildlife species to many Montanans and are cherished as both a trophy animal and species that fosters memories of wildlife encounters long remembered” (2010a, 3).



Figure 2.13. Land management agencies commonly feature bighorns on wildlife viewing interpretive signs designed for the public. Photograph by author.

## **Biology of the Bighorn-Domestic Sheep Disease Connection**

### **Introduction**

The fact that bighorn-domestic sheep interaction often leads to fatal bighorn disease is well-established, despite some uncertainties about precise transmission components (Brigham, Rominger, and Espinosa T. 2007). Every state in the western U.S. has hosted disease-caused bighorn die-offs, which commonly occur after wild sheep interact with domestic sheep (DBC Technical Staff 1990). However, significant bighorn die-offs may occur with no well-documented cause, or domestic sheep interaction may be likely but unproven (Arthur et al. 1999; WAFWA 2010a). Interaction is often not observed because of the remoteness, ruggedness, and lack of human presence common in bighorn ranges (George et al. 2008).

### **Disease Strains and Infection Factors**

Bighorn disease outbreaks regularly impact wild sheep of all ages and kill many or most of a population's individuals (USFS 2006). Bighorn disease die-offs can strike the animals quickly, killing them within a few days. However, die-offs can also last months with bighorns gradually sickening before losing their battle with illness (MFWP 2010a).

While “bighorns + domestic sheep = many dead bighorns” is often a valid general conclusion, the equation is not that simple. Bighorns can experience disease die-offs without contacting domestic sheep, and bighorns may sometimes mingle with domestic sheep without fatal illness or without immediately getting ill (BLM 1999; Aune et al. 1998). Bighorns can also carry strains of pneumonia bacteria without dying or displaying observable symptoms, and various biological and ecological factors (weather, parasites,



nutrition, etc.) could worsen or mitigate illness (Malmberg, Nordeen, and Butterfield 2008).

Numerous diseases (e.g., scabies, worm parasites, bluetongue, soremouth, etc.) from domestic sheep can kill bighorns, but pneumonia is one of the most frequent and prominent bacterial afflictions of wild sheep (DBC Technical Staff 1990; Tomassini et al. 2009). Various strains of pneumonia bacteria can prove fatal to bighorns, and disease risk varies with different types of microbes (Tomassini et al. 2009; Heimer 2002).

*Mannheimia haemolytica* (formerly classified as *Pasteurella haemolytica*) has proven to be one of the deadliest bacteria bighorns face (Tomassini et al. 2009; Heimer 2002; Lawrence et al. 2010). It is commonly found in domestic sheep and is rarer in bighorns (George et al. 2008). In the remainder of this thesis, microbial pathogens causing pneumonia are simply referred to as “pneumonia bacteria.”

Just how close do wild and domestic sheep need to be for disease transmission? Scientists have generally assumed nose-to-nose contact was necessary, but wind tunnel experiments indicate bacteria could be transmitted between domestic and wild sheep without direct contact (Dixon et al. 2002).

Some important disease transmission factors stand out that highlight bighorns’ special susceptibility. One factor is that domestic sheep are often healthy during and after fatal infection of bighorns (DBC Technical Staff 1990). Domestic sheep can carry pneumonia bacteria that do not harm them but are deadly to wild sheep (George et al. 2008). Healthy domestic sheep can fatally infect bighorns because bighorns are a New World species with more compromised immunity, likely because they did not evolve

with the Old World microorganisms to which domestic sheep have gradually adapted (Subrimaniam et al. 2011a; DBC Technical Staff 1990).

Another important aspect of wild-domestic sheep disease transmission is that an illness's effect on individual bighorn populations can be long-lasting. Pneumonia outbreaks usually suppress wild sheep lamb recruitment for years after an all-age die-off (USFS 2006). For example, after a 1970s disease outbreak in California's Santa Rosa Mountains, bighorn lambs regularly died from pneumonia, poor recruitment continued for 13 years, and the adult population decreased by 81 percent from 1979 to 1996 (DeForge et al. 1982, 1997).



Figure 2.14. Bighorn lambs can be particularly susceptible to domestic sheep pneumonia. Photograph by Stratton (NPS 2012b).

Suppressed lamb recruitment also occurred after Montana's Lower and Upper Rock Creek bighorn populations suffered severe pneumonia die-offs in the winter of 2009-2010. By 2011, the number of yearlings per 100 ewes in the Rock Creek

populations had dropped by 96 percent (WAFWA 2010a; Crowser 2011). Apparently, pneumonia especially deadly to lambs comes from ewes that stay infective after an outbreak, even though such pathogenicity may not be detectable (Cahn et al. 2011).

#### Bighorn-Domestic Sheep Disease Transmission Evidence

Numerous studies involving penned bighorn and domestic sheep have confirmed a fatal disease connection (Wehausen, Kelley, and Ramey II 2011). Proven bighorn-domestic sheep disease transmission in the wild has also been documented, and anecdotal cases are abundant (Jeffress 2008; Barker 2009; Brigham, Rominger, and Espinosa T. 2007). For a sampling of bighorn die-offs associated with domestic sheep, see Appendices A-D.

One of the most compelling captivity studies was described in a 2010 *Journal of Wildlife Diseases* article entitled: “Transmission of *Mannheimia haemolytica* from domestic sheep (*Ovis aries*) to bighorn sheep (*Ovis canadensis*): Unequivocal demonstration with green fluorescent protein-tagged organisms” (Lawrence et al. 2010). In this study, scientists marked *M. haemolytica* isolates from four clinically normal domestic sheep with a plasmid containing green fluorescent protein genes. Via intranasal spraying, the tagged isolates were then colonized back into the four sheep they came from. The marked domestic sheep were kept 10 m (33 ft) away from four bighorns for one month. During that time, scientists did not observe pneumonia symptoms in the bighorns (Lawrence et al. 2010).

The marked domestic sheep were then permitted to have fence-line contact with bighorns for two months. In that time, three bighorns contracted marked bacteria from domestic sheep. After the two months of allowed fence-line contact, scientists let the

bighorns and domestic sheep mingle (Lawrence et al. 2010). Lawrence et al. describe what happened next: “All four bighorn sheep died 2 days to 9 days following commingling. The lungs from all four bighorn sheep showed gross and histopathologic lesions characteristic of *M. haemolytica* pneumonia. Tagged *M. haemolytica* were isolated from all four bighorn sheep” (2010, 706). The researchers went on to state: “These results unequivocally demonstrate transmission of *M. haemolytica* from domestic to bighorn sheep, resulting in pneumonia and death of bighorn sheep” (Lawrence et al. 2010, 706).



Figure 2.15. Bighorns penned with domestic sheep as part of a captivity study. Photograph by U.S. Forest Service (USFS 2001).

Notable captivity studies also occurred prior to 2010. For example, in 10 planned pen experiments (results published in 1988, 1989, 1990, and 1994) conducted by three independent research groups, domestic sheep remained healthy, and all “23 bighorn

sheep tested . . . died of respiratory disease following contact with domestic sheep, or were euthanized when close to death” (Wehausen, Kelley, and Ramey II 2011, 10).

Evidence for one-sided, fatal wild-domestic sheep disease transmission also comes from an unplanned 1980 disease outbreak that occurred in a penned bighorn population at Lava Beds National Monument in northern California. In 1971, wildlife managers transplanted bighorns to a 5.4 km<sup>2</sup> (1,334 acre) pen in the Monument. As Wehausen, Kelley, and Ramey II explain: “In 1980, nose-to-nose contact was observed through the enclosure fence between bighorn sheep and domestic sheep grazed on adjacent National Forest lands. Bighorn sheep began dying of pneumonia 2-3 weeks later and all 43 bighorn subsequently died” (2011, 10).

Much of the disease transmission evidence associated with cases of free-ranging bighorns is anecdotal. At the Desert Bighorn Council’s (DBC) 2007 meeting, William R. Brigham (retired biologist) discussed wild-domestic sheep disease transmission and referred to “reams of anecdotal cases . . . dating all the way back to the 1800s” (Brigham, Rominger, and Espinosa T. 2007, 1). Wehausen, Kelley, and Ramey II elaborate on the historical context of bighorn disease associated with domestic sheep:

The large region where bighorn sheep extirpations have been so widespread coincides spatially with where domestic sheep have been grazed in North America, and temporally with the beginning of that grazing. While one cannot infer cause and effect from spatial and temporal correlations alone, it has long been hypothesized that diseases transferred from domestic sheep were a key factor in the widespread loss of bighorn sheep populations. For example, the principal cause of the first large-scale population losses in the 19<sup>th</sup> century was attributed to scabies introduced by domestic sheep, based largely on clinical evidence of scabies in bighorn sheep during die-offs, and the temporal association of these scabies outbreaks with the introduction of domestic sheep. (2011, 9)

According to the DBC’s technical staff: “Documented bighorn die-offs were recorded as early as the mid-1800s” (1990, 33). What follows is a small sampling of

some of these anecdotal cases. Toweill states: “Early records tell of massive die-offs of California bighorns [in Idaho]: one near the community of Jordan Valley in the winter of 1884-85, another along the Owyhee River (due to ‘scab’ following the initial introduction of domestic sheep into that country) [in] about 1902” (Toweill and Geist 1999, 134). Toweill also remarks: “Records indicate that [Owyhee County] supported a minimum of 150,000 [domestic] sheep by 1898” (Toweill and Geist 1999, 134).

In 1988, a pneumonia-caused die-off completely extinguished a reintroduced bighorn population in northeastern California’s Warner Mountains, and domestic sheep were believed to be the source of the outbreak pathogens (Bleich et al. 1990). In the early 1990s, a die-off occurred among northeast Utah’s Beaver Creek bighorn population shortly after one of its rams spent time with domestic sheep. The population of about 80 to 90 bighorns was reduced to 10 animals (Shannon et al. 2008).

A devastating bighorn pneumonia die-off in a region hosting domestic sheep struck Montana’s Elkhorn Mountains in 2008 (Byron 2008; MFWP 2010a). Additionally, in the winter of 2009-2010, a total of about 890 bighorns in several states died because of pneumonia—some of which may have been spread by domestic sheep (WAFWA 2010a).

An example of proven open range wild-domestic sheep disease transmission occurred in Nevada in 1994. In the Trout Creek Mountains, a bighorn ewe mingled with 23 domestic rams for fewer than 24 hours. Wildlife managers captured the bighorn ewe within 17 hours of her documented domestic sheep interaction. They then translocated the ewe out of the wild, and five days later, she died from pneumonia. Tissue and swab samples taken from the dead bighorn ewe revealed bacteria isolates that were identical to those taken from all 23 domestic rams documented with her earlier (Jeffress 2008).



### Exclusivity of Domestic Sheep as Fatal Disease Vector

In studies testing the disease risks various cohabiting wildlife and livestock species pose to bighorns, domestic sheep stand out as being most harmful, though domestic goats (*Capra hircus*) can also be fatal. Management policies for bighorn-domestic sheep interaction also apply to domestic goats (Wehausen, Kelley, and Ramey II 2011). Exotic Old World ungulates can be fatal to bighorns, and cattle pose a somewhat uncommon pneumonia threat (Wehausen, Kelley, and Ramey II 2011; Wolfe et al. 2010; McAdoo, Wolff, and Cox 2010).



Figure 2.16. Bighorn ewe with domestic goats near Douglas, Wyoming. Photograph by Justin Binfet, Wyoming Game and Fish Department.

Despite disease threats from other animals, this project focuses on domestic sheep. Bighorns and domestic sheep are closely related, capable of interbreeding, and more likely to interact with each other than other species (Cahn et al. 2011; Miller et al. 1995). During the breeding season, young bighorn rams tend to travel great distances in

search of ewes (e.g., up to 64 km [40 mi]), and their wanderings can bring them in contact with domestic sheep pathogens, which they can pick up and return to their wild herds (Valdez and Krausman 1999; DBC Technical Staff 1990; USFWS 2007).



Figure 2.17. Desert bighorn ram with domestic sheep in Arizona's Dome Valley. Photograph by Bob Henry, Arizona Game and Fish Department.

Bighorn rams are sometimes attracted to domestic ewes, and interspecies breeding has occurred (Aune et al. 1998). For example, "in Montana, at least 4 cases of young rams breeding with domestic sheep have been reported since 1990" (Aune et al. 1998, 62). In one case in Wyoming, a young bighorn ram got into a domestic sheep flock, and his efforts resulted in five hybrid lambs. Two died not long after birth. Two others were taken to a research facility where they soon died. One lamb survived and grew to become a mature ram that lived with the domestic sheep but often escaped his pen (Hurley 2012).



Commercial domestic sheep herds grazing on public land have been emphasized as a threat to wild sheep, but farm flocks, hobby animals, and herds used for vegetation control can also kill bighorns (Hurley et al. 1999; USFWS 2007; Erickson, Coggins, and Alt 2000).



Figure 2.18. Young bighorn rams bedded with domestic ewes. Photograph by John Kanta, South Dakota Department of Game, Fish, and Parks.

#### *A Vaccine Solution?*

Bighorn vaccine trials aimed at combating respiratory disease have been largely unsuccessful such that vaccination does not seem to be a realistic solution to the disease problem (Wehausen, Kelly, and Ramey II 2011). Advocates of Congressional bighorn management restrictions (introduced in 2011 for the sake of the domestic sheep industry) promulgated the notion that such restrictions would give sheep producers relief from regulation while a vaccine is developed that would protect bighorns while allowing them to live near domestic sheep (Hirai 2011; IPT 2011a).

However, in 2011, Washington State University researcher Subrimaniam Srikumaran claimed that if all went well, a field vaccine would not be ready sooner than 10-15 years from then (Hirai 2011; WSF 2011b). An October 2011 article (coauthored by Srikumaran) published in *Clinical and Vaccine Immunology* describes a vaccine experiment in which four treated bighorns were successfully protected against *M. haemoloytica* while four untreated bighorns died within 48 hours of infection (Subrimaniam 2011b).

A bighorn vaccine could be developed and administered through food (Hirai 2011). Nonetheless, vaccinating domestic sheep would be more practical (WSF 2011c). Although both wild and domestic sheep would require field trials, Srikumaran's research focuses on decreasing the amount of pathogens shed by domestic sheep (WAFWA 2011a). The WSF has helped fund this research, and the American Sheep Industry Association (ASI: a domestic sheep advocacy group) has also performed funding efforts for a vaccine solution (WAFWA 2011a; Hinson 2012).

#### Nationwide Regional Trends: 1990-2010

U.S. bighorn disease outbreaks have varied depending on subspecies and state. Based on the U.S. Fish and Wildlife Service's (USFWS) 2007 Sierra bighorn management plan and an absence of reports while thoroughly searching for bighorn disease incident information, from 1990-2010, Sierra Nevada bighorns suffered no documented disease outbreaks. In the same 21-year time period, Rocky Mountain bighorns suffered far more outbreaks than other subspecies. From 1990-2010, desert bighorns experienced fewer outbreaks than bighorns in the Rockies, and California bighorns suffered even fewer documented outbreaks than desert bighorns (Arthur et al.

1999; Jansen et al. 2007; Torres, Bleich, and Wehausen 1996; Buchanan 2008; Cassirer et al. 1996; WAFWA 2010a; Byron 2008; Malmberg, Nordeen, and Butterfield 2008; NDOW 2011; Cummings and Stevenson 1998; Ward et al. 1997; Miller et al. 1995; Rominger and Goldstein 2007; ODFW 2003; Merwin and Brundige 2000; Olson et al. 2008).

When comparing the 15 bighorn-hosting states to each other, Montana and Nevada stand out as having an especially high number of outbreaks (WAFWA 2010c; Byron 2008; Arthur et al. 1999; NDOW 2011; Cummings and Stevenson 1998). For example, in just the winter of 2009-2010, four different Montana bighorn populations experienced pneumonia outbreaks (WAFWA 2010c). These numbers are exceptional for a single state because, according to Utah Division of Wildlife Resources Director Jim Karpowicz: “In a bad year, there may be two or three bighorn die-offs somewhere in the West” (WAFWA 2010a, 1).

The political/administrative climate in Montana helps explain why so many die-offs occurred there. In a newspaper article covering development of Montana’s first comprehensive bighorn management plan (released in 2010), Person stated that “groups already fighting to get domestic sheep off public land complain that the Department of Fish, Wildlife and Park’s [*sic*] first-ever bighorn sheep conservation strategy keeps woolgrowers in the drivers’ seat when it comes to determining where bighorn sheep can and can’t roam” (2009).

From 1990-2010, Idaho also experienced exceptionally high levels of bighorn disease-related mortalities, but the number of well-documented individual outbreaks discovered was fewer than that for Montana or Nevada (Cassirer et al. 1996; Arthur et al.

1999; Toweill and Geist 1999; IDFG 2010). Some Idaho bighorn populations are particularly susceptible to die-offs because of the highly contiguous nature of much of that state's wild sheep habitat (Jeffress 2012b).

In 1990, about 3,850 Rocky Mountain bighorns roamed Idaho, but pneumonia outbreaks occurring in the 1990s reduced this number to an estimated 1,700 Rocky Mountain bighorns by 1998 (IDFG 2010; Toweill and Geist 1999). That decline of over 50 percent has apparently significantly depressed bighorn populations ever since (ID WSF 2012). By 2012, an estimated 1,900 Rocky Mountain bighorns lived in Idaho, representing little net growth over the previous 14 years (ID WSF 2012). Significant population growth and recovery would be expected for a healthy population.

California bighorn decline in Idaho has been less substantial—going from about 1,460 in 1997 to an estimated 1,000 animals in 2012 (IDFG 2010; ID WSF 2012). The Idaho Wild Sheep Foundation has reported that a lack of emphasis on wild-domestic sheep separation policies and a state-level political climate largely unfavorable to bighorns contributed to Idaho's dramatic declines (ID WSF 2012).

Arizona, California, and Nebraska had the fewest documented outbreaks (Arthur et al. 1999; Jansen et al. 2007; Torres, Bleich and Wehausen 1996; Malmberg, Nordeen, and Butterfield 2008). The Hells Canyon region (with afflicted sub-populations in Idaho, Oregon, and Washington) was the single metapopulation area that experienced the most disease outbreaks from 1990-2010 (Arthur et al. 1999; Cassirer et al. 1996). For a snapshot of the varying prominence of the wild-domestic sheep disease issue in different states across the West, see Table 2.1 on the next page.

Table 2.1. Continental U.S. results of wild sheep status questionnaires prepared for 2nd North American wild sheep conference: Adapted from Appendix A of proceedings, Y= Yes, N = No; *Source:* Arthur et al. 1999

State: Bighorn subspecies	Livestock grazing or domestic sheep listed as state/federal relationship challenge?	Livestock grazing or domestic sheep addressed in answer to question of: "What do you do to detect, manage, and/or prevent disease (e.g., disease screening at capture)?"	Domestic sheep or grazing listed as a significant limiting factor?	Disease die-off in last 5 years?	Disease die-off in last 25 years?	Survey respondents
Arizona: Rocky Mtn.	Y	N	N	N	N	Raymond Lee
Arizona: Desert	Y	N	N	N	N	Raymond Lee
California: California*	N	N	N	N	Y	Steven G. Torres
California: Desert	N	N	N	N	Y	Steven G. Torres
Colorado: Rocky Mtn.	Y	N	Y	Y	Y	John Ellenberger
Colorado: Desert	Y	N	N	N	N	John Ellenberger
Idaho: California	Y	N	N <sup>1</sup>	N	Y	John Beecham
Idaho: Rocky Mtn.	Y	N	N <sup>2</sup>	N	Y	John Beecham
Montana: Rocky Mtn.	Y <sup>3</sup>	N	N <sup>4</sup>	Y	Y	John J. McCarthy
Nebraska: Rocky Mtn.	N	N	N <sup>5</sup>	N	?	Gary Schlichtemeir
Nevada: California	Y	N	N	N	N	Craig Mortimore
Nevada: Desert	N	Y	N	? <sup>6</sup>	Y	Patrick Cummings & Craig Stevenson
Nevada: Rocky Mtn.	Y	N	Y	Y	Y	Larry T. Gilbertson
New Mexico: Desert	Y	N	N	N	Y	Eric Rominger
New Mexico: Rocky Mtn.	Y	N	N	? <sup>7</sup>	Y	Bill Dunn
North Dakota: California	Y	N	Y	Y	Y	Mike Oehler
North Dakota: Rocky Mtn.	N	N	N	Y <sup>8</sup>	N	Ted A. Benzon
Oregon <sup>9</sup> : California	Y	Y	Y	N	Y	Don Whittaker
Oregon: Rocky Mtn.	N	N	Y	Y	Y	Don Whittaker
South Dakota: Rocky Mtn.	N	N	N	Y	N	Ted A. Benzon
Texas: Desert	N	N	N	N	N	Doug Humphreys
Utah: California	N	N	N <sup>10</sup>	N	N	Jim Karpowitz
Utah: Desert	Y	N	N <sup>11</sup>	N	Y	Jim Karpowitz
Utah: Rocky Mtn.	Y	N	N <sup>12</sup>	Y	N	Jim Karpowitz
Washington: California	Y	N	Y	N	Y	George Tsukamoto
Washington: Rocky Mtn.	Y	N	Y	Y	N	George Tsukamoto
Wyoming: Rocky Mtn.	N	N	Y	Y	Y	Kevin Hurley

1. "Disease/die-offs" listed
2. "Disease/die-offs" are listed.
3. Merely "over grazing" is listed
4. "Disease" is listed
5. "Disease" is listed.
6. Response not provided. However, suspected disease die-off in late 1990s is mentioned.
7. "Maybe"
8. Benzon answers yes, but mentions die-off occurring in Badlands National Park, which is actually in South Dakota.
9. Oregon specifically mentions domestic sheep in answers to all three major categories.
10. "Possible disease" listed.
11. "Disease" is listed.
12. "Disease" is listed.

## **Bighorn-Domestic Sheep Interaction Management Policies: An Overview**

### **Introduction**

Wildlife agencies and land managers did not seem to widely recognize the threat domestic sheep pose to bighorns until about the late 1980s (Brigham, Rominger, and Espinosa T. 2007; Hurley et al. 1999). In parts of the 1980s, there were many unknowns regarding the issue of bighorns getting disease from livestock. Accelerated bighorn reintroduction efforts—with various transplants happening in areas with and without domestic sheep—sped up the development of biologists’ understanding of the wild-domestic sheep disease problem (Tanner 2012a).

Dynamic and conflicting scientific theories contributed to such understanding. However, some official recognition of the disease problem existed prior to the late 1980s. For example, in 1954, CDOW bought land in bighorn habitat at Pikes Peak to prevent domestic sheep grazing. By 1967, California’s San Bernardino and Angeles National Forests had a policy against grazing domestic sheep on range occupied by bighorns (USFS 2006). California was among the first states to really investigate the disease threat (Tanner 2012a). Furthermore, in 1981, the Director of Wildlife and Fisheries for the USFS sent regional foresters a memo emphasizing that they should exercise “appropriate caution” to prevent bighorn-domestic sheep contact (USFS 2006, 4). Once the disease threat was well-recognized, management agencies adopted policies to ensure the separation of wild and domestic sheep (WAFWA 2007).

The USFS, BLM, and state wildlife management agencies have their own policies for wild-domestic sheep interaction (WAFWA 2007). Wildlife managers’ policies largely

relate to addressing bighorns' distributions. Land managers' policies primarily relate to regulating domestic sheep grazing on public lands (WAFWA 2010c).

### *Evolving/Conflicting Causal Theories*

For context on bighorn-domestic sheep interaction policies, it is helpful to analyze the history of such policies and how wildlife managers' understanding of wild sheep disease has evolved. In an informal essay presented at the Northern Wild Sheep and Goat Council's 2002 symposium, bighorn biologist Wayne E. Heimer provides a summary:

The presence of pneumonia die-offs in bighorn sheep prior to European settlement of North America is unknown. With European settlement of the American West, pneumonia die-offs became the dominant factor in management and restoration of Rocky Mountain and California bighorn sheep. Early work suggested lungworm parasites were *the causal factor*, and the "lungworm-pneumonia complex" was taught as causative in wildlife and ecology curricula for decades . . . . Presuming parasites were causal, antihelminthic drugs were seen as the treatment. The drugs purged bighorns of parasites in laboratory conditions, but pneumonia die-offs persisted in the wild. Eventually, enough die-offs were statistically and pathologically associated with domestic sheep presence that domestic sheep replaced the "lungworm-pneumonia complex" as *the causal factor*. Managers then generally presumed that bighorn pneumonia die-offs would end if domestic sheep were excluded from bighorn ranges. Still, bighorn pneumonia die-offs were reported in bighorn populations with no documented exposure to domestics. (2002, 154)

Heimer further notes: "This finding caused some tension between the 'domestic-caused' [or "germ theory"] . . . and 'stress-caused' . . . camps of pneumonia die-off researchers" (2002, 154). Researchers believing bacteria were the main causal factor in bighorn pneumonia have mainly been located in the Pacific Northwest (Heimer 2002). Scientists placing more emphasis on stress (brought on by parasites or other forces) as a causal factor have generally been further east. According to Heimer, they have mainly been in "Colorado and Wyoming, the region where the work on the lungworm/pneumonia complex dominated research for almost 40 years" (2002, 158). The

germ theory camp of the bighorn disease issue was dominant in 2002, partly because evidence for the germ theory is direct while stress research is more inferential (Heimer 2002).

Research performed for this thesis shows the germ theory camp was still dominant in 2013. Nonetheless, material in the Wildlife Management Institute's 1978 book, *Big Game of North America: Ecology and Management*, reflects the former dominance of the lungworm/stress theory. In the chapter on bighorns, Wishart remarks: "During periods of stress, bighorns historically have suffered catastrophic die-offs, particularly in the Rocky Mountains. In recent decades, the principal cause of death invariably has been pneumonia with the nematode lungworm *Protostrongylus* strongly implicated" (1978, 167). In the entire subsection entitled "Parasites and Diseases," Wishart does not mention domestic sheep at all. After discussing drug treatment efforts in Colorado, he notes: "Bighorn managers recognized that they were treating symptoms of a problem that had developed from overprotected and overcrowded ranges where sheep were being exposed continuously to lungworm infections" (1978, 168). Bighorn population thresholds likely play a role in pneumonia outbreaks, but domestic sheep are currently acknowledged as a dominant cause of pneumonia in wild sheep (Hurley 2012).

In addition to the Wildlife Management Institute's book, another 1978 publication illustrates the biological understanding of bighorn pneumonia in the decade before domestic sheep were widely implicated. Robert P. McQuivey discussed the bighorn disease problem in *The Desert bighorn Sheep of Nevada*, which is an 81-page biological bulletin published by the Nevada Department of Fish and Game (NDFG 1978). The document contains brief sections on disease and livestock competition. These sections



indicate the domestic sheep threat was not well-recognized or understood in 1978. McQuivey emphasizes scabies, lungworm, and stress in addition to pneumonia as bighorn limiting factors. Domestic sheep presence correlating with scabies is also addressed (NDFG 1978). However, McQuivey makes some remarks that highly contrast with current management attitudes and reflect the limited state of disease knowledge at the time. He notes:

Pneumonia is not considered to be a contagious disease in the desert sheep populations of Nevada, or an ailment that needs to be treated. An analysis of the habitat requirements for bighorn in relation to sheep numbers and other limiting factors shows that pneumonia is one of the natural means by which populations are controlled. If pneumonia was eliminated from sheep populations, another mortality factor would need to be operative in order to keep population levels in balance with existing habitat. (NDFG 1978, 55)

McQuivey states that “severe overgrazing by and competition for forage with domestic livestock is considered to be the single most important factor affecting the disappearance of bighorn sheep from Northern and Central Nevada and in localized areas in Southern Nevada” (NDFG 1978, 55). McQuivey heavily emphasizes that bighorn disappearance across the state has corresponded with the arrival of domestic livestock, including sheep. However, competition for forage and range damage are offered as the primary explanations for such disappearances (NDFG 1978). In what is an especially telling statement in hindsight, McQuivey notes: “The severity of competition between domestic sheep and the native bighorn is evidenced by the fact that no bighorn populations exist anywhere in the State where domestic sheep are currently being grazed” (NDFG 1978, 57). Times have changed. Bighorns and domestic sheep now share significant portions of Nevada and other parts of the West (WSF 2012a). This coexistence has led to tension.

Politically-fueled tension has existed between the germ theory and stress research camps because the germ theory camp has emphasized excluding domestic sheep from bighorn ranges. The stress camp has been less supportive of separation and has wanted to place more emphasis on disease-related factors other than domestic sheep (Heimer 2002). According to Heimer: “The political power of the domestic sheep industry in the ‘germ’ and ‘stress’ regions is variable, and the differences over the necessity of eliminating domestic grazing . . . lead the ‘germ’ folks to consider the ‘stress’ folks less as colleagues with a differing approach, and more as ‘domestic sheep sellouts’” (2002, 159).

#### *Necessity of Bighorn-Domestic Sheep Separation*

Most management policies regarding wild-domestic sheep interaction focus on preventing it (WAFWA 2010b). The necessity of bighorn-domestic sheep separation has been well-established (Mack 2008; Dubay et al. 2002; Wehausen, Kelley, and Ramey II 2011). Wildlife managers and researchers widely accept that a deadly incompatibility exists between wild and domestic sheep, and they also widely support separation to prevent catastrophic bighorn population losses (Mack 2008). However, acceptance of these factors was not always so common (Hurley et al. 1999).

Biologists analyzed the bighorn-domestic sheep separation issue during a discussion at the 2<sup>nd</sup> North American Wild Sheep Conference in 1999 (Hurley et al. 1999). During the discussion, bighorn biologist Tim Schommer stated: “If you look at the 1970s, we, as a group, put reintroduced bighorn sheep in a lot of areas right on top of domestic sheep. In general, the problem was most of us didn’t have a clue what we were doing” (Hurley et al. 1999, 287). Schommer elaborated on how the problem got recognized and how disbelief persisted well into the 1990s:

In the 1980s, Nike Goodson came out with a paper [Goodson 1982] that she was beat up pretty good on, concerning the incompatibility between the two species. A lot of people challenged her and it proved out through the 1980s that she was right. I spent a tremendous amount of my personal career trying to get the acknowledgement of the disease problem to people all over the West. It's not just this group that needs to be educated. There's still a lot of people that are in denial, mainly the [grazing] permittees and a lot of the land managers that I have to deal with. That was really elevated in the early 1990s by . . . DNA fingerprinting . . . . I think we've got most of the people convinced that it's a problem and we need to keep wild and domestic sheep separated. That's been a huge undertaking especially with our land managers. (Hurley et al.1999, 288)

By 2008, bighorn-domestic sheep interaction was a management concern in 14 of the 15 western states where bighorns occur (Mack 2008).

### Major Policies

Some major bighorn-domestic sheep interaction management policies involve buffer zones (up to 13.5 km [8.4 mi] according to the BLM's 1998 guidelines), livestock supervision, and domestic sheep trailing restrictions (BLM 1999; DBC Technical Staff 1990). The BLM defines trailing as "domestic livestock walking from one location to another under the control of one or more herders" (2012a, 1). Essentially, with sheep trailing, the animals are relocated via overland herding instead of some other method (e.g., trucks, trains, etc.). Additional interaction policies include prohibition of bighorn reintroduction to sites hosting domestic sheep, buying out/altering grazing allotments, education and negotiation, and the removal (often fatal) of wandering bighorns that get close enough to domestic sheep to pose a risk of disease contraction (BLM 1999; DBC Technical Staff 1990; Heimer 2000; Hurley et al. 1999; Mack 2008). These policies will be examined in more detail later in this thesis in the context of six different case study locations.

Schommer provides insights on public land separation practices based on his experience as a biologist with the USFS:

Each allotment includes grazing practices specific to the allotment and permittee and each allotment carries its own set of unique circumstances that need to be evaluated. What works in one location may not work in another. The following factors affect the success or failure of a grazing practice: topography, bighorn sheep source habitat connectivity, bighorn sheep population size, proximity of domestic sheep grazing allotments to bighorn sheep populations, timing of allotment use, density of vegetation, and escape terrain. None of the [practices] can be determined effective without an active monitoring effort to detect the presence or absence of bighorn sheep near domestic sheep bands. (USFS 2010b, 1)

Schommer also states: “Agreeing to [policies] on paper is easier; implementing them on the ground for the entire grazing season year after year is more difficult. Many examples of [practices] not always being implemented on the ground exist. And [practices] can only be effective if fully implemented and readily adapted if not working” (USFS 2010b, 3). The rugged nature of bighorn habitat increases the difficulty of effective separation policy implementation (USFS 2010b). Schommer provides an example of how policy efficacy can be elusive:

On the Temperance Creek Allotment in Hells Canyon in the 1980s and early 1990s, domestic and bighorn sheep were separated by over 20 air miles and almost all of the [best management practices] described [in USFS 210b] were implemented. Despite these grazing practices and large separation distances, the two species could not be kept apart. Detecting bighorn and domestic sheep in this open, rocky, continuous bighorn sheep habitat was very difficult. Known mixing . . . approximately every other year resulted in large catastrophic bighorn sheep die-offs. (USFS 2010b, 3-4)

The policies just addressed are some of the major ones that stand out. However, regarding bighorn-domestic sheep separation, there are numerous strategies (e.g., double fencing, cartographic risk assessments, notification requirements, etc.). The Wild Sheep Working Group (WSWG) of the Western Association of Fish and Wildlife Agencies

(WAFWA) provides many more examples in its recommendations, which are some of the most comprehensive, up-to-date documents focusing solely on bighorn-domestic sheep interaction management (WAFWA 2007, 2010c, 2012b).



Figure 2.19. Domestic sheep are often grazed in remote, rugged terrain like this portion of the Colorado Rockies. Photograph by Bureau of Land Management (BLM 2009).

### Federal Agency Trends

In 1999, regarding the disease issue, USFS biologist Melanie Woolever stated: “There’s a lot of resistance by the leadership of our agency to address it. The livestock industry has traditional power within our agency and in the Legislature in the states in the

West. They're very effective and it's been one of those things that has been pushed aside unless the situation was critical" (Hurley et al. 1999, 287). She added: "We're not wanting to put the livestock industry out of business. They own base property that we'd rather see in their hands than condos or 5-40 acre ranchettes" (Hurley et al. 1999, 287). While the USFS has not always confronted the bighorn-domestic sheep disease issue, in 2001, it released *A Process for Finding Management Solutions to the Incompatibility Between Domestic and Bighorn Sheep*. This is an informative 64-page document authored by agency bighorn biologists. It provides an overview of the disease issue, discusses collaborative resolution approaches, features possible solutions, and includes some example bighorn-domestic sheep management strategies (for particular national forests) as appendices (USFS 2001).

Despite reluctance, the USFS was forced to directly confront the disease issue when environmental advocacy groups sued them in the 1990s and numerous times afterward for failing to protect bighorns from domestic sheep (NWF 1995; Hoffman 2007). Much of this litigation focused on Hells Canyon and Idaho's Payette National Forest (Barker 2011a). According to Hoffman: "[In April 2007] . . . The Wilderness Society, an Idaho-based anti-grazing group called the Western Watersheds Project, and the Hells Canyon Preservation Council sued the Forest Service for failing to protect a viable population of bighorn sheep" (2007). Hoffman adds: "Faced with the lawsuit, the Payette National Forest quickly turned around and agreed to a bighorn-protection plan drawn up by the Nez Perce Tribe" (2007).

Some motivation for litigation came from the fact that about 20,000 domestic sheep grazed on the Payette National Forest in 2007. Also, Hells Canyon bighorns were

spending time on the Forest's domestic sheep grazing allotments with wild sheep from Oregon regularly crossing the Snake River (Hoffman 2007). Hoffman says states "have transplanted more than 600 [bighorn] sheep up and down Hells Canyon since the 1970s, with a goal of having 2,000 bighorns in the huge Hells Canyon Initiative area by [2007]" (2007). Hells Canyon held about 840 bighorns in 2010 (HCBSRC 2010). After 1995-1996 Hells Canyon disease outbreaks, pneumonia continued to be a problem for Hells Canyon bighorns (Cassirer et al. 1996; Cockle 2008). In 2007, 80% of the bighorn lambs in Hells Canyon died from pneumonia (Cockle 2008).

Litigation involved with the Payette National Forest was based on the species viability provision of the National Forest Management Act (NFMA) (Hoffman 2007). The 1982 NFMA rules require that: "Fish and wildlife habitat shall be managed to maintain *viable populations* of existing native and desired non-native vertebrate species in the planning areas" (Rasband, Salzman, and Squillace 2009, 1243). The Act also notes that "habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area" (Rasband, Salzman, and Squillace 2009, 1255).

Lawsuits eventually led to significant agency research, risk analysis, and the controversial Payette decision limiting domestic sheep grazing in the area (Barker 2011a; Pramuk 2010). However, implementation of that decision was delayed in 2012 because of the USFS's interpretation of a Congressional rider Idaho Representative Mike Simpson tacked onto the annual Interior and Environment Appropriations bill in 2011 (Barker 2011b; U.S. Congress 2011; Pramuk 2012). Later in 2012, a judge overruled the USFS delay of the Payette decision (Cole 2012).

The BLM directly addressed the bighorn-domestic sheep disease issue on an agency-wide scale earlier than the USFS. In 1989, the BLM asked the technical staff of the DBC to develop guidelines (Appendix F) for domestic sheep management in bighorn ranges (BLM 1995b; DBC Technical Staff 1990). With the collaboration of bighorn and domestic sheep experts, the BLM augmented and revised these guidelines in 1992 (Appendix G) and 1998 (Appendix H). Among revisions were a focus shift to all bighorns (not just desert bighorns) and a clause about the domestic sheep industry being held harmless if bighorn disease occurs when special agreements are in place (BLM 1995a, 1999).



Figure 2.20. BLM range manager and sheep producer discuss grazing in Colorado. Photograph by Bureau of Land Management (BLM 2009).

The BLM also touches on the bighorn-domestic sheep disease problem in its 1995 *Mountain Sheep Ecosystem Management Strategy in the 11 Western States and Alaska* (1995). This document approaches bighorn management from a broad ecosystem-wide



perspective and includes the BLM's 1992 version of its main wild-domestic sheep management guidelines. It also features results of a survey submitted to bighorn managers. The results provide a glimpse of how much disease was a limiting factor for different bighorn subspecies on various types of land (BLM, other federal land, state, and private). The results show prioritization rankings (on a scale of one to three) of limiting factors for bighorns along with what percent of biologists ranked certain factors a particular way. For example, disease was ranked as the number one population limiting factor for Rocky mountain bighorns on BLM lands by 35 percent of respondents and the number one population limiting factor for Rocky Mountain bighorns on private lands by 48 percent of respondents. Habitat condition limiting factors were also assessed, and 69 percent of respondents ranked grazing as the number one Rocky Mountain bighorn habitat limiting factor on BLM lands (BLM 1995).

As of May 2009, local BLM office managers and state BLM offices had discretion regarding sheep separation policy (WAFWA 2009). For example, BLM offices in Cody, Lander, and Worland, Wyoming, had “fully acknowledged/referenced” (WAFWA 2009, 3) solid recommendations released by WAFWA while a field office in Butte, Montana had “completely ignored those recommendations, and continued to permit/advocate/allow conflicting activities in close proximity to occupied [bighorn] habitats” (WAFWA 2009, 3).

The USFWS directly addresses the disease issue in its management of federally endangered bighorn populations (USFWS 2000, 2007). Bighorns protected under the Endangered Species Act (ESA) can be much safer than the average wild sheep. The ESA is a sweeping piece of legislation that allows science to seep into numerous facets of

natural resources management across the country. As Rasband, Salzman, and Squillace remark:

The most powerful federal law, and perhaps the most powerful law in the whole field of natural resource management, is the 1973 Endangered Species act (ESA) . . . . The ESA embodies America's commitment to protect wildlife by mandating the dedication of resources and the tempering of development. The ESA intersects with (and trumps) many other natural resource management regimes. Its impacts are felt literally across the country—whether through red cockaded woodpeckers in Southeastern pine forests, salmon in Pacific Northwest rivers, desert tortoises in Southwest land developments, or gray wolves in the Intermountain West. (2009, 348)

According to Nie: “The ESA asks scientists to answer questions that they are often not comfortable answering” (2012a, 45). These questions often involve scientific disagreement, uncertainty, and risk analysis. Some environmental advocacy groups also use the ESA as a surrogate to force scientific scrutiny onto topics like private land development, energy consumption, climate change, agency missions, etc. (Nie 2012a, b).

Bighorns in California have received special scientific attention because of ESA protections. For example, in its 2000 recovery plan for Peninsular desert bighorns, the USFWS acknowledges that domestic sheep seriously threaten bighorns, and it mentions prohibiting domestic sheep grazing within 14.5 km (9 mi) of bighorn habitat (USFWS 2000). Endangered Species Act protection has also motivated the formulation of more effective policies for protecting endangered Sierra Nevada bighorns from domestic sheep. The USFWS provides detailed separation recommendations in its 2007 Sierra bighorn recovery plan (USFWS 2007). Numerous stakeholders and agencies in the Sierra have also collaborated to develop a risk assessment for Sierra bighorn-domestic sheep contact (CDFG 2009). Additionally, the USFWS has closed some domestic sheep allotments in the Sierra. In the Lee Vining area, tracking collars have been placed on Sierra domestic

sheep to monitor their proximity to bighorns, and herders have had to follow special supervision rules involving sheep counts, extra dogs, and reporting requirements (Reiterman 2005).

## **Controversy of Bighorn-Domestic Sheep Interaction Management**

### **Introduction**

Though conflicts have heated up in recent years, controversy over wild sheep management is not new. According to Bleich and Weaver:

When V. C. Bleich began work with [the California Department of Fish and Game] in 1973, he raised some questions about the status and conservation of those unique ungulates, and a high-level administrator responded that, ‘We don’t talk about them, because they are controversial and the subject is politically sensitive.’ (2007, 55-56)

Thirty-four years later, bighorn disease researcher William J. Foreyt stated: “The biology is very clear, but the politics change by the month” (Hoffman 2007).

In addition to science, the bighorn disease controversy largely relates to politics and cultural tension between locals and government agencies. For example, regarding a proposed early 1990s bighorn reintroduction to New Mexico’s Caballo Mountains, biologist Amy Fisher stated: “Public comment was overwhelmingly negative . . . Full-page cartoons in local newspapers depicted a bighorn surrounded by a cyclone fence, implying that bighorn would preclude all human activities” (1993, 57).

The DBC’s technical staff notes that “several potential bighorn reintroductions in Nevada have been contested by the livestock industry . . . They contend that bighorn reintroductions will seriously hamper their ability to graze livestock of their choice on public lands” (1990, 33). In the summer of 2010, when bighorns in Nevada were experiencing die-offs, NDOW did not meet with a nearby domestic sheep permittee

because of the current political climate in the state (WAFWA 2010d). Additionally, “[NDOW] caught hell from one of their new Commissioners” for killing a bighorn that came into contact with domestic sheep (WAFWA 2010d, 2).

The upset commissioner may have been domestic sheep rancher Hank Vogler, who was appointed to the Nevada Wildlife Commission in July 2010 while also serving on the Nevada Board of Agriculture (Associated Press 2010). According to an Associated Press article: “Vogler criticized wildlife biologists for killing a bighorn sheep he nicknamed ‘Chin Creek Chin,’ after biologists learned the ram frequently mixed with Vogler’s domestic sheep” (2010). Vogler also stated that killing the bighorn was “‘political assassination’ and wrote, ‘How embarrassing to have a wild sheep mingle with domestic sheep and not die instantly as the pseudo-science seems to suggest’” (Associated Press 2010). The Associated Press article added that regarding the bighorn-domestic sheep disease connection and problem, “Vogler disputes those theories as myths based on old science and an attempt by some to push livestock operators off public lands” (2010).

Managing wild-domestic sheep interaction can be difficult. According to Heimer, “a bighorn manager must face the down and dirty work associated with negotiating, establishing, and maintaining separation of bighorns from domestic sheep . . . . This is hard administrative work, and not a particularly preferred activity for field biologists or administrators in states with traditions of domestic sheep ranching” (2000, 133). With conflicts, emphasis is placed on managing domestic sheep because controlling domestic sheep movements is easier and more practical than controlling wild sheep (DBC Technical Staff 1990).



Figure 2.21. Domestic sheep grazing has become a cultural tradition in some parts of the American West. Photograph by Bureau of Land Management (BLM 2009).

#### *Economic Consequences for Sheep Producers*

Domestic sheep restrictions based on bighorn protections directly impact a small portion of the American public. According to a Payette National Forest presentation at a February 2010 meeting of WAFWA's WSWG, fewer than 50 families in the western U.S. run domestic sheep on occupied public land bighorn habitat (WAFWA 2010e). Furthermore, only four sheep producers on the Payette National Forest were directly affected by the Payette decision (IPT 2011a). In 2009, Idaho Department of Fish and Game (IDFG) Director Cal Groen said IDFG determined 18 domestic sheep ranchers in Idaho used areas where bighorn contact was possible (E. Barker 2009). Despite being a small group, domestic sheep ranchers in bighorn country have big worries (Hoffman 2007).

In recent years, decreased sheep production in Australia and New Zealand and increased demand in East Asia have driven up the price of lamb and made U.S. sheep production more important (Blaney 2011; Orr 2012). However, some of these increased profits have been threatened by bighorns (Hoffman 2007). According to Margaret Soulen Hinson (current ASI president), the approximately one million acres of national forest bighorn habitat hosting domestic sheep grazing represent about 25 percent of U.S. domestic sheep production (Hinson 2012; IPT 2011a). Hinson argues that limiting domestic sheep production because of bighorns could trigger cascading economic decline impacting both domestic sheep producers and associated industries (wool mills, meat packers, etc.) (IPT 2011a). Despite recent price increases, by November 2012, wholesale lamb prices (those that ranchers charge) had reached record low numbers. Possible explanations for the price drop include: recent drought conditions, high prices dissuading consumers, satiated demand, increased lamb imports, and potential price fixing (Guerin 2012).

While some sheep producers can lose money by losing grazing land access, others may reap significant short-term monetary gains by selling out their grazing privileges to bighorn advocacy groups (Hoffman 2007). Among other areas across the West, this strategy was tried in the Payette region (Toweill and Geist 1999; Hoffman 2007). However, there, buyout efforts were greeted with refusal. For example, WSF tried to buy sheep rancher Ron Shirts's grazing permit for \$250,000, but he refused because he was holding out for \$2.5 million (Hoffman 2007).

*Livestock Industry's General Questioning of Science*

The domestic sheep industry's opposition to bighorn disease science has gotten to the point where industry representatives have espoused denialistic paradigms regarding the threat domestic sheep pose to bighorns (Hurley et al. 1999). Clifford et al. state:

Despite evidence that domestic sheep diseases threaten the persistence of bighorn sheep populations, the economic consequences of restricting domestic sheep grazing has polarized the debate, with some arguing that disease risk posed by domestic sheep has been exaggerated and grazing restrictions should be eased. (2009, 2559)

The controversy over bighorn-domestic sheep disease risk has been compared to the climate change issue where clear science is clearly denied (Hoffman 2007). The MFWP notes:

Across the west where bighorn sheep occur there often is controversy where that distribution overlaps with domestic animals, particularly domestic sheep. The controversy stems from the concept that when domestic sheep or goats come together with bighorn sheep the bighorn sheep often die. While supported by research and widely recognized, this concept is not accepted by all parties. (2010a, 3)

Not all domestic sheep advocates openly question the science of the bighorn-domestic sheep disease connection. For example, ASI president Margaret Soulen Hinson knows transmission happens and that it can be important to separate wild and domestic sheep (IPT 2011b; Barker 2011a). However, she thinks more research on bighorn stressors and disease is important. She is also skeptical that total wild-domestic sheep separation is possible without putting some sheep ranchers out of business (Barker 2011a). Additionally, regarding a 2011 bighorn-domestic sheep workshop put on by ASI, bighorn biologist Kevin Hurley said that no workshop attendees publicly doubted or denounced wild-domestic sheep separation (WAFWA 2011b).



### Credentialed Skepticism

Annette Rink (DVM, PhD) has been one of the few credentialed researchers to seriously question the disease threat of domestic sheep. Rink is the director of the Nevada Department of Agriculture's Animal Disease and Food Safety Laboratory in Reno (Hoffman 2007; NDA 2012). According to Hoffman: "In a September 2006 memo [to then Interior Department Deputy Assistant Secretary Julie McDonald], Rink wrote that disease transmission from domestic to bighorn sheep is a 'legend' and a 'perception perpetuated by some individuals'" (2007). More detail on Rink's skepticism of bighorn disease science is in her exclamation mark-clad critique of the USFS's 2006 Payette National Forest risk assessment (Rink 2011). This document was posted online as supporting material for a September 2011 Nevada Wildlife Commission meeting (NDOW 2012a).

One of the most outspoken credentialed bighorn disease science critics is Marie Bulgin (DVM, MBA) who is a University of Idaho (UI) professor emeritus of veterinary medicine and was the coordinator of UI's Caine Veterinary Teaching Center in Caldwell from 2003-2010. She has also been an Idaho Wool Growers Association president (Barker 2009; Hoffman 2007; Miller and Bonner 2009; CVTC 2012). Bulgin and other Caine Center colleagues questioned the validity of captivity experiments demonstrating domestic sheep's disease threat to bighorns because they happened in pens instead of the wild where circumstances are different (Hoffman 2007).

However, Bulgin and the Caine Center became the subjects of a UI conflict of interest investigation begun in 2009 after she testified multiple times before the Idaho legislature and in federal court that evidence documenting disease transmission from

domestic sheep to bighorns in the wild did not exist. Bulgin's statements were not factual because studies described in an unpublished paper showed otherwise. In fact, the research proving Bulgin's statements incorrect was conducted at the Caine Center (Barker 2009).

Journalist Rocky Barker explains:

The unpublished paper discussed two different bighorn sheep, a ewe found with domestic rams in Nevada and a bighorn ram found grazing with domestic ewes in Oregon. Both died after they were brought to the Caine Center and isolated in 1994. The same strains of the bacteria *pasteurella* were found in the domestics and the wild sheep in both cases. [Though never actually published,] the paper was accepted for publication in the *Journal of Wildlife Diseases* in 1997. (2009)

Clearly publicized controversy over the studies' paper started during a 2007 meeting where Caine Center scientists questioned the wild-domestic sheep pneumonia bacteria connection (Barker 2009). While holding the unpublished paper, David Jessup (a senior wildlife veterinarian for the California Department of Fish and Game in 2009) called out Alton Ward (a Caine Center researcher) and said: "I don't have to prove anything. You proved it yourself at your own lab" (Barker 2009). Jessup noted: "Once confronted with it, he realized it was a major mistake and said they would go back and modify the paper and resubmit it" (Barker 2009).

Bulgin worked at the Caine Center in 1994 and became its director in 2003 (Miller 2009). According to Barker: "Scientists involved in the study said a series of personnel issues and changed assignments kept the paper from publication, not politics" (2009). Bulgin claimed to have not been aware of the research, but one of the paper's co-authors, Dave Hunter (former IDFG veterinarian), had trouble believing that (Barker 2009). In fact, Bulgin's daughter was a Caine lab technician in 1994, and she aided with DNA analysis involved with the open range transmission studies (Miller and Bonner 2009).

Retired NDOW biologist Jim Jeffress was involved with transporting one of the studies' bighorns, and he wrote an abstract on the Nevada bighorn death analysis, which is discussed in the evidence section of this document (Jeffress 2008). The studies have still not been officially published. However, researchers have been busy expanding and revising an article covering the free-range studies (Jeffress 2012b). The article should be published in the near future. Nonetheless, I have been informed that politics has delayed its publication in prominent journals, which could face severe political backlash if they publish findings unfavorable to the domestic sheep industry.

In 2010, UI cleared Bulgin of scientific misconduct and allowed her to continue Caine Center duties, though she retired from the Center that year (Miller 2010; CVTC 2012). In 2010, Bulgin also emphasized that stress was more likely to cause bighorn illness than domestic sheep (Miller 2010). In 2009, Bulgin stated: "I'm not against bighorn sheep. I'm just for agriculture" (Miller 2009). More detail on Bulgin's skepticism of bighorn disease research can be found in "A Review of Bighorn Sheep Articles used for the Payette DSIES [*sic*]" (Bulgin and Urbigkit 2011). It is a 24-page critique presented with a UI letterhead and posted on NDOW's website as supporting material for a portion of a September 2011 state Wildlife Commission meeting focused on the history of bighorns in the Great Basin (Bulgin and Urbigkit 2011; NDOW 2012a).

## Chapter III: Methodology

### **Introduction**

This study employed mixed methods, including case studies and policy analysis relying on extensive secondary research. Once case study locations and policy analysis criteria were decided, answers were sought via literature, semi-structured interviews, and questionnaires. Final results were analyzed with tables and comparisons.

### **Scope Narrowing and the Case Study Approach**

Numerous bighorn die-offs happened in the western U.S. from 1990 to 2010. See the tables in Appendices A-D for examples. To gain orientation on just what happened and what could be feasibly researched, listings of major bighorn disease outbreaks by state were compiled. Sources for such listings and other background information include: proceedings of the Northern Wild Sheep and Goat Council and Desert Bighorn Council's (DBC) meetings, state bighorn management plans, scientific journals, news articles, federal government documents, and Western Association of Fish and Wildlife Agency (WAFWA) reports.

Compiling and analyzing lists of disease incidents helped with settling on a case study approach focusing on six discrete die-off cases or events. This approach yielded a cross-sectional representation of wild-domestic sheep policies across the western U.S. Such representation was a research goal because it seemed a suitable avenue for compiling useful results in an achievable manner. The multiple case study approach allowed in-depth of analysis of particular events and their situations in particular locations. Such an approach also produced results that can be generalized for speculation on trends in broader regions. Examining one event would produce results with too narrow

of a scope for this project's aims, and even a cursory analysis of all discovered 1990-2010 disease outbreaks would not be practical because of limits on time and information availability. Thus, a case study methodology focusing on six events was deemed an effective and feasible way to approach this project's questions. Additionally, such an approach allows for easy organization of data in forms suitable for comparisons and analysis.

Moreover, the case study approach fit well with the habitat use patterns of wild sheep. Bighorns often live in isolated populations in specific areas (e.g., individual mountain ranges, canyons, rims, etc.). They also tend to stick to one general area their entire lives (Toweill and Geist 1999). Thus, the case study approach fit well with the behavior of bighorns, and any areas examined were sure to have continuously hosted wild sheep for a significant amount of time before a disease outbreak.

Once context was acquired on just where and when most bighorn disease outbreaks occurred, this project's geographic-temporal scope was narrowed with the aim of presenting a roughly cross-sectional representation intended to yield diverse, useful results. The timeframe of 1990-2010 was chosen for several reasons. The major Bureau of Land Management (BLM) policies for bighorn-domestic sheep interaction management (compiled by the DBC) were first presented in 1990 (DBC Technical Staff 1990). Furthermore, because the disease threat was not widely recognized until about the late 1980s (Brigham, Rominger, and Espinosa T. 2007; Hurley et al. 1999), 1990 is a fitting starting point for examining policy. By 1990, many managers should have had at least a fair idea of what various disease risks were in their respective locations and what could be done to reduce them.

With an upper bound of 2010, the scope of the topical and dynamic subject of bighorn disease is limited to ensure feasibility. Notable die-offs and news articles have continued beyond 2010, but keeping up with them and incrementally incorporating them into this project would have proved challenging. The capping date of 2010 was also chosen because updated recommendations from WAFWA for domestic sheep management in bighorn habitat were released in 2010, and they reflect how policy has evolved since 1990 and what should now be known. Additionally, the winter of 2009-2010 marked one of the most infamous in documented history for bighorn pneumonia outbreaks. About 890 bighorns (from nine populations in five states) died: a grim but relevant timeframe finale (WAFWA 2010c). One area (Bonner/West Riverside) that was part of this cluster of die-offs was chosen as a case study location.

With a methodology and timeframe established, the geographic scope of the research was narrowed via the selection of case study locations. Colorado, Montana, Nevada, and Oregon were chosen as states on which to focus. These states represent a large sampling of bighorn habitat and collectively host all subspecies that suffered disease outbreaks from 1990-2010. These states also experienced enough documented outbreaks to provide sufficient material for case studies, and they each have a bighorn management plan (CDOW 2009; MFWP 2010a; NDOW 2001; ODFW 2003).

Case studies of specific 1990-2010 outbreak locations are the main foci of this project. However, as the background chapter illustrates, the scope for the overall investigation includes the entire western U.S. from primarily the mid-1800s to 2013. The bighorn-domestic sheep disease issue covers vast stretches of time and space.

## **Rationale for Case Study Choices**

The six case study locations were selected based on: information availability; presence of domestic sheep; and temporal, geographic, and subspecies representation. All locations hosted reasonably well-documented die-offs and nearby domestic sheep. Collectively, in general, locations are also chronologically, spatially, and taxonomically representative of bighorn die-offs across the West. Data availability was an important factor in choosing locations. Regions with more outbreak data available were more likely to be chosen. Information on bighorn disease outbreaks is often incomplete, and the role of domestic sheep can be implied, unclear, or nonexistent. Some 1990-2010 outbreaks were attributed to domestic goats (Cassirer et al. 1996; Jansen et al. 2007). For this project, only locations with nearby domestic sheep were chosen. By focusing on areas with domestic sheep, a consistent series of analysis criteria are generally applicable to almost every location.

Locations were also chosen with a goal of temporal representation such that they reflect the middle, upper, and lower portions of the 1990-2010 timeframe. Chosen outbreak occurrence years include: 1991, 1994-1995, 1997-2000, 2007, and 2010. This temporal sampling reveals insights on policy evolution. Subspecies representation was another goal. The breakdown of subspecies per disease outbreak location is: three Rocky Mountain bighorn locations (two in Montana and one in Colorado), two California bighorn locations (Nevada and Oregon), and one desert bighorn location (Nevada). Rocky Mountain bighorns, Nevada, and Montana are disproportionately represented because that subspecies and those states experienced especially high numbers of outbreaks from 1990-2010.



## **Case Study Locations**

Google Earth was used to perform a cursory analysis of each location's position (Figure 3.1). These analyses provided general context on the biophysical and cultural attributes for each region. Such context was useful for later research. Additionally, the analyses made clear where case study locations were located relative to each other. This information verified the geographically broad and representative nature of the case study areas.

For Nevada, the Tobin range (respiratory bacterial infection of desert bighorns begun in 1991) and Hays Canyon Range (2007 pneumonia outbreak in California bighorns) were chosen (Arthur et al. 1999; Cummings and Stevenson 1995; NDOW 2008a). For Montana, the Highland/Pioneer Mountains (1994-1995 pneumonia outbreak) and Bonner/West Riverside (2010 pneumonia outbreak) were chosen (Arthur et al. 1999; Aune et al. 1998; WAFWA 2010b). The Highland/Pioneer Mountains were chosen partly because their bighorns lived near domestic sheep for about 20 years with no serious disease issues (Aune et al. 1998). That coexistence factor offered potential for especially insightful findings on interaction management. Bonner/West Riverside was chosen because its bighorns live near mixed-use human development, which adds a unique dimension to management issues (WAFWA 2010b). For Colorado, the Tarryall/Kenosha Mountains (1997-2000 pneumonia outbreak) were chosen, and for Oregon, Aldrich Mountain (1991 pneumonia outbreak) was chosen (George et al. 2008; ODFW 2003).



Figure 3.1. Locator map of case study locations.

## **Compiling Results**

For each case study location, profiles were compiled that include examinations of the following categories.

- Biophysical geography and land ownership (presented under the subheading of “Introduction”)
- Bighorn population history prior to outbreak
- Nearby domestic sheep
- Disease outbreak in question
- Applicable policy documents
- Answers to policy analysis questions

For examining biophysical geography, each location’s position, general topography, and vegetation are described. For land ownership, major land owners/managers of bighorn habitat are listed and discussed with occasional emphasis (when available data permits) on how much bighorn habitat each entity owned/managed. Pre-outbreak bighorn population histories are also described. These include details on: population establishment, growth and management, and population size just prior to examined epizootics.

When examining nearby domestic sheep at the time of each outbreak, the location and circumstances of sheep presence are discussed. Proximity to bighorns is addressed along with whether domestic sheep were free-ranging allotment stock, hobby animals, weed control mechanisms, etc. When summarizing case study disease outbreaks, elements addressed are: chronology, disease strains, presumed infection causes, agency responses, and post-outbreak population estimates.

## **Policy Analysis**

The policy analysis approach is the most effective way to analyze the bighorn-domestic sheep disease and management issue because it focuses on evolving policy during a period of time in which numerous die-offs occurred and thus provides a better understanding of policies that can improve bighorn health and prevent disease.

Investigating policy documents was an important part of the policy analysis process. Analyses of policy documents include summaries and commentaries on important documents relevant to each outbreak. Sometimes, policy literature that did not fit neatly into the answers to the policy analysis criteria questions is described in the “Policy Documents” section. Bighorn-domestic sheep interaction management policies were analyzed by applying nine criteria (on pages 83-84) to each case study location. Criteria are presented as a series of questions with certain sub-questions dependent upon answers. Questions apply to the timeframe up to and including each outbreak.

Policy analysis criteria #1-4 were taken from the 1990 BLM guidelines for domestic sheep management in desert bighorn habitat (DBC Technical Staff 1990). Criteria #5-8 were based on other literature (Hurley et al. 1999; ODFW 2003; Mack 2008). Criterion #4 was not applied to the Tarryall/Kenosha Mountains because this is the only case study location hosting a native bighorn population that was not established through transplants (Toweill and Geist 1999; CDOW 2009; NDOW 2010). Some criteria also ended up not being applicable to certain locations because of a lack of domestic sheep grazing allotments on public land (USFS 2007; Rohrbacher 2012).

For criteria questions presented in the results, answer headings are included below each criterion to provide organization. These headings include: “Answer and Explanation

(yes or no and why), “Answer and Implementation” (how policies were enforced/presented), and “Policy” (summaries of and excerpts from actual policies). For criteria #8-9, because of different question tones, answer headings include “Answer and Nature” instead of “Answer and Implementation.” After certain questions were answered, answer headings sometimes changed based on particular answers. For example, if a certain policy did not exist or was never carried out, “Answer and Explanation” is used instead of “Answer and Implementation,” and “Policy” may not be included if no policy details are available. As illustrated on pages 83-84, the questionnaires submitted to respondents included basic what/how follow-up questions based on yes/no responses. After answering each policy analysis criterion question, a policy efficacy summary is presented for each location.

Criterion #9 (regarding the possibility of funding difficulties) requires some special commentary because it is a more generalized question that does not primarily involve a specific sheep regulation element like most of the other criteria. One might wonder just what types of bighorn-domestic sheep interaction management could have benefited from better funding? For one thing, funding could have determined the level and effectiveness of staff to enforce grazing regulation policies. For example, better funding could have put BLM personnel on the range during sheep drives to monitor their proximity to bighorns. Additionally, funding could also pertain to education efforts regarding wild-domestic sheep interaction. For instance, maybe not enough money is always available to do thorough community outreach to address the threat of hobby domestic sheep. Separation barriers (e.g., electric fences) could also be funded by government money. Additionally, special wild-domestic sheep interaction monitoring

programs like that carried out by the City of Missoula (described in the Bonner/West Riverside case study) need funding.

Before contacting agency representatives, many questions were answered or partially answered via literature. Most respondents who were interviewed via e-mail and/or the phone received partially completed questionnaires that contained the questions listed below. These questions often formed entire questionnaires or contributed to questionnaires. They were also the basis of semi-structured phone interviews that sometimes went well beyond the scope of initial questions.

*Policy Analysis Criteria*

1.) *Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?*

YES: How large were they? Did they take topographic barriers into consideration? Were they enforced? If so, how?

NO: Why?

2.) *Were special supervision rules in place for shepherders?*

YES: What were they? How were they enforced/presented?

NO: Why?

3.) *Were domestic sheep trailing restrictions in place to ensure separation?*

YES: What were they? How were they enforced/presented?

NO: Why?

4.) *Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?*

YES: What policies were in place or what consideration was taken?

NO: Why?

5.) *Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?*

YES: What were the efforts?

NO: Why?

6.) *Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?*

YES: How?

NO: Why?

7.) *If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?*

YES: What were the circumstances?

NO: Was this policy considered?

8.) *Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?*

YES: What was the nature of this coordination and/or tension?

NO: Why?

9.) *Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?*

YES: What was the nature of these difficulties?

NO: Why?

### **Finding Answers**

Answers were first sought via literature. State bighorn management plans, national forest plans, and BLM land and resource management plans were particularly helpful. Results of a questionnaire presented to biologists at the 2nd North American Wild Sheep Conference in 1999 (see Table 2.1 on page 52) were also insightful for gauging general levels of agency coordination and tension that existed in the middle of the study timeframe (Arthur et al. 1999).

When literature left gaps, government agencies were contacted. Before completing case study profiles, contact information was gathered for agency offices near each outbreak location. Agencies contacted included the BLM, U.S. Forest Service (USFS), Colorado Parks and Wildlife (CPW), Montana Department of Fish, Wildlife, and Parks (MFWP), Nevada Department of Wildlife (NDOW), and Oregon Department of Fish and Wildlife (ODFW). Finding contact information for BLM employees was the easiest. BLM district websites have convenient, thorough staff directories that are easy to locate. Contacting USFS and state wildlife agency personnel was more challenging, and contact information was less available.

At least one land management agency and one wildlife management agency were contacted for each location. Varying land ownership patterns dictated what agencies got contacted. For example, for the Tobin Range, just the BLM and NDOW were contacted. However, for Aldrich Mountain, the BLM, Malheur National Forest, Ochoco National Forest, and ODFW were contacted.

In general, when contacting agency personnel, inquiries were first made via phone or e-mail to agency representatives knowledgeable about their colleagues (information and education managers, front desk people, etc.). After asking initial contacts about who might best be able to answer this project's questions, certain specialists (mainly wildlife biologists and rangeland managers) were contacted until willing questionnaire respondents were discovered. Questionnaires were then sent via e-mail and returned electronically or conveyed verbally on the phone. Some agency personnel were more responsive than others. Some agency people completely ignored inquiries. Other personnel were quickly responsive, and some agency workers responded to follow-up communication initiated several weeks or months after initial contact attempts. A couple of retired agency wildlife biologists also proved particularly helpful.

The Surprise BLM Field Office in northeastern California managed domestic sheep grazing near bighorn habitat in Nevada's Hays Canyon Range and committed some of the most obvious policy mistakes/violations (Flores, Jr. 2012; BLM 2007a, b). However, surprisingly, personnel at that office were exceptionally responsive and informative compared to other locations.

Not much information was clearly or easily available concerning policy at the time of the Aldrich Mountain die-off because it happened over 20 years ago. However,



agency personnel were helpful and even investigated some things on their own. Finding information regarding the Tobin Range was also challenging because it is an obscure location that experienced a disease outbreak over 20 years ago. Nonetheless, contacting a retired NDOW biologist (Gregg Tanner) contributed to significant filling of data gaps for the Tobin Range.

For some of the older outbreaks, just because certain policies were not discovered in this study or known of by some agency personnel does not necessarily mean they did not exist. However, by remaining unknown at this point, certain policies may not have been prominent or important. Finding data concerning the most recent studied disease outbreak locations (Hays Canyon Range and Bonner/West Riverside) was the easiest, and much data exist concerning wild-domestic sheep management in those areas.

## **Discussion of Results**

Discussion of results (presented in Chapter V) focuses on evaluating policy efficacy. The essential question is: What location/policy combinations were the most and least prone to cause or prevent bighorn disease? Some locations had logical policies that were not enforced. Certain policies also did not exist for some regions. Factors like this were considered as the results were analyzed from a comparison perspective to gauge policy efficacy.

For each case study profile category (nearby domestic sheep, disease outbreaks, etc.), tables were made to summarize key findings in a manner that facilitated clear comparisons. With the aid of tables, commentary was then compiled that analyzes the meaning of the results for each category. Results for the nine policy analysis criteria receive individualized commentaries in addition to a summary table covering all criteria.

The policy analysis commentaries include discussions of the general policy efficacy of each of the major criteria. Conclusions in these discussions were determined by case study results. The general criterion efficacy analyses are followed by location-specific commentaries. In these commentaries, some key location results are repeated and summarized to serve as examples illustrating efficacy trends. Policy similarities and differences between locations are also frequently covered. The policy analysis criteria commentaries are followed by some general discussion of overall temporal trends.

## Chapter IV: Results

### SECTION 1 – TOBIN RANGE, NEVADA: 1991

#### Introduction

The Tobin Range (40° 26' 1.36"N, 117° 29' 50.94"W) is located in eastern Pershing County in north-central Nevada (Google Earth 2012; USFS 2012b). This fault-block mountain range is about 48 km (30 mi) southeast of Winnemucca (BLM 2012b; Google Earth 2012). According to the BLM's 1995 mountain sheep ecosystem management strategy, about 97 percent of the Tobin Range bighorn habitat bioregion is BLM land, and 3 percent is private land (BLM 1995). The Tobin Range is part of the Tobin Range Wilderness Study Area (WSA) managed by the Bureau of Land Management (BLM). This WSA includes "13,107 acres of public lands and surrounds 120 acres of private lands" (BLM 2012b, 1). Elevations within the WSA range from 1,414-2,979 m (4,640-9,775 ft). The BLM provides further details on the Tobin Range:

The upper elevations (7,000-9,700 feet) are characterized by smooth, dominant ridges separated by shallow drainages. The foothill section has roughly parallel (east-west) deeply-cut drainages and several dominant rock outcrops and is bounded on the west by a prominent fault scarp 10 to 20 feet high, formed in 1915. This fault was exposed during a major earthquake. The lowest section, the fringing desert piedmont, is a gently sloping alluvial fan on the east side of Pleasant Valley, with several parallel, east-west drainages separated by low ridges. (2012b, 1)

In the Tobin Range, sagebrush (*Artemisia* spp.) is the main vegetation above 2,134 m (7,000 ft), and big sage (*Artemisia tridentata* Nutt.) dominates below 2,134 m (NDOW 2012b, d; NRCS 2012b, 2002). Juniper trees (*Juniperus*) and small riparian areas also exist in the Tobin Range's lower elevations (BLM 2012b).

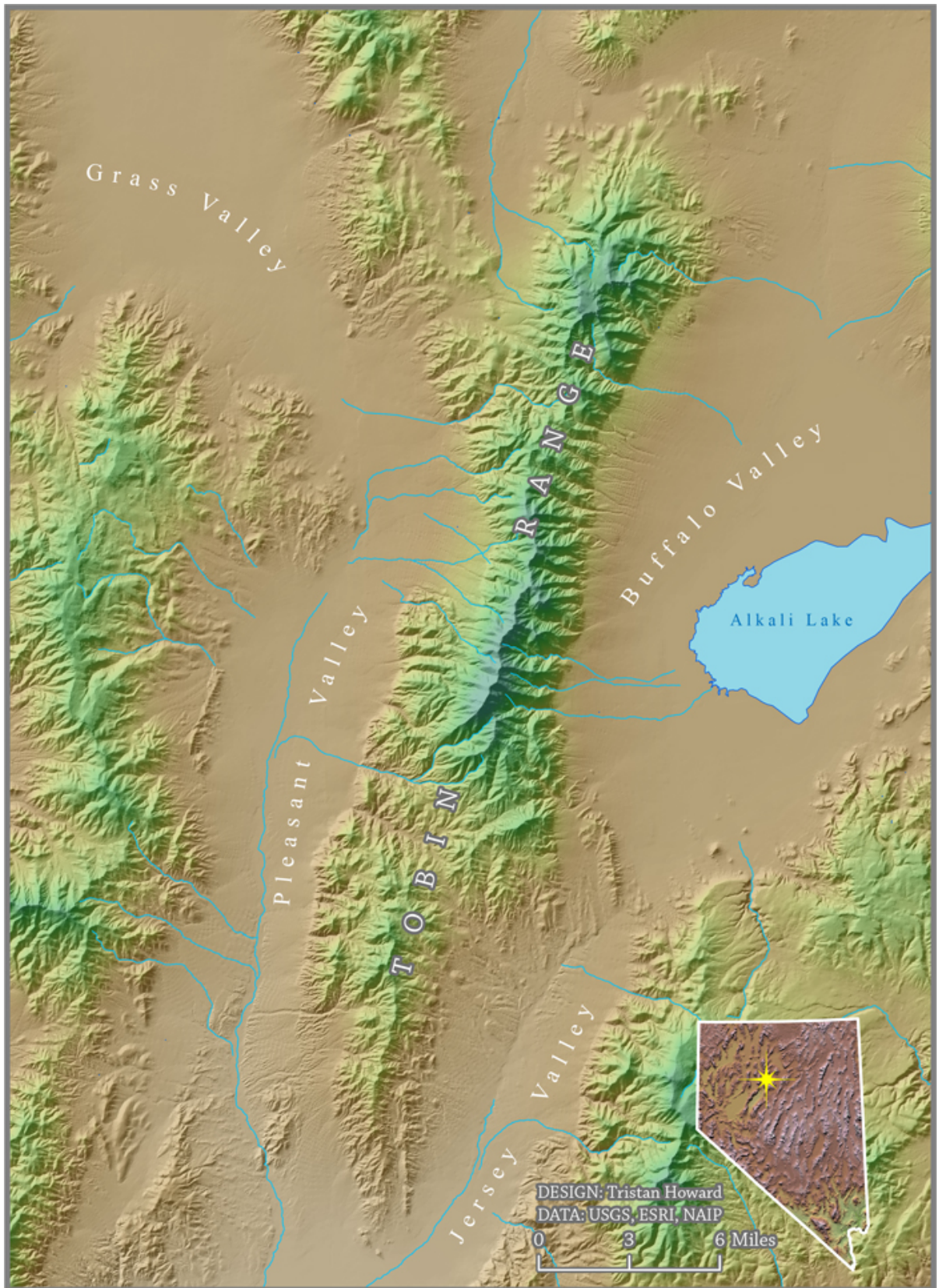


Figure 4.1. Tobin Range terrain.



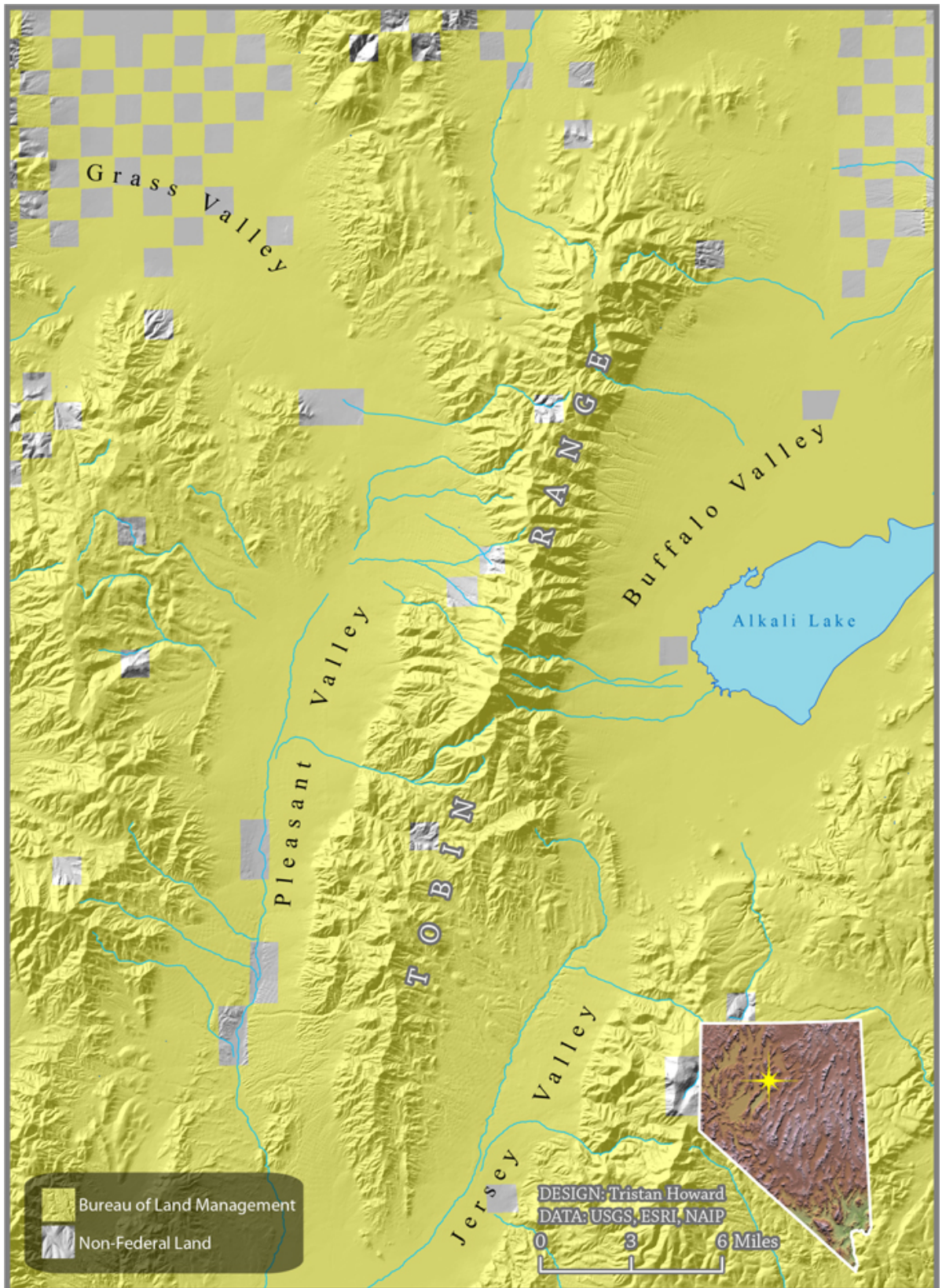


Figure 4.2. Tobin Range federal land ownership.

In 1984, desert bighorns were reintroduced to the Tobin Range (NDOW 2010). Domestic sheep roamed a nearby private ranch during the time of the Tobin Range disease outbreak, and bighorn-domestic sheep interaction was observed in the area prior to its disease event (Ward et al. 1997; Tanner 2012a). In the early 1990s, respiratory disease eliminated all Tobin Range bighorns (Cummings and Stevenson 1995). A variety of BLM documents (including a management framework plan, desert bighorn plan, and guidelines for managing domestic sheep in desert bighorn habitat) applied to the Tobin Range at the time of its bighorn die-off (BLM 1982, 1989, 1990). A Nevada Department of Fish and Game (NDFG) biological bulletin on the state's desert bighorns was also relevant (NDFG 1978). In the 1980s-1990s, influential litigation transpired, which dealt with the threat domestic sheep posed to bighorns in the Tobin Range (*Joe Saval Co. v. BLM and NDOW* 1991).

Regarding wild-domestic sheep interaction policies, the Tobin Range lacked clear buffers, special sheepherder supervision rules, and trailing restrictions (Tanner 2012a). Nonetheless, domestic sheep presence was considered before reintroduction, grazing allotment alteration was implemented, and negotiation or education occurred (BLM 1982; DBC Technical Staff 1990; Jeffress 2012a; Tanner 2012a). Bighorns near domestic sheep were not removed from the area (Tanner 2012b). Agencies managing Tobin bighorns also coordinated their management activities and did not experience significant tension or funding difficulties (Tanner 2012a, b). For sufficient context on the Tobin Range's wild-domestic sheep interaction policies, it helps to know the history of the area's desert bighorns before respiratory disease triggered their demise.

### *Bighorn Population History Prior to Outbreak*

The Tobin desert bighorn population was established in 1984 when 34 bighorns from southern Nevada's River Mountains were released into Miller Basin (NDOW 2010; Google Earth 2012). In October 1991, wildlife managers transplanted 18 additional bighorns from the Black Mountains near Lake Mead to Indian Canyon in an effort to augment the Tobin population (Ward et al. 1997; NDOW 2010). Just how large did the Tobin population get right before it experienced disease? That is unknown. According to Nevada Department of Wildlife (NDOW) Regional Supervising Biologist Mike Dobel: "I have no records of population estimates during this time frame as it was an un-hunted population which did not require published estimates in our yearly status and trend books" (2012b). Though their numbers may not have been clear, in the mid-1980s, desert bighorns once again roamed the Tobin Range, *but* they were not the only sheep in the neighborhood.

### *Nearby Domestic Sheep*

At the time of the Tobin outbreak, a domestic sheep flock existed on a ranch adjacent to the Tobin Range (Ward et al. 1997). According to Ward et al.:

A portion of this flock grazed on the Tobin Range during the preceding summer. The length of time that the domestic sheep were on the various ranges was not known. It is estimated that domestic sheep trespassed on the Tobin Range for 2 to 4 [weeks] during the 1991 grazing season. Interaction of bighorn sheep and domestic sheep on the Tobin Range was probable but the duration of contact is unknown. (1997, 545)

Gregg Tanner provides more detail on the domestic sheep situation in the Tobin Range during the 1980s and early 1990s. However, before delving into that material, it is relevant to provide context on his background because he serves as a primary information source for much of the policy analysis later in this section.

Tanner retired from the NDOW in 2004 with the statewide position of Game Bureau Chief. He was NDOW's Supervising Game Biologist for Region 1 in 1984 when managers released bighorns onto the Tobin Range. Tanner supervised all game management programs in Nevada's nine northwest counties. He was the biologist in charge of overseeing the Tobin reintroduction. However, he was not a primary field biologist for the project. He worked with Phil Benolkin (another NDOW biologist) who was actually on the ground (or in the air via helicopter) when important events unfolded (Tanner 2012a).

While performing wildlife surveys via helicopter, NDOW biologists often saw stray domestic sheep on the range. The NDOW flew more missions than other wildlife agencies—often for statewide mule deer surveys in fall and spring. This put biologists in a good position to spot stray domestic sheep that were left on the range by operators who were done grazing in particular areas. The NDOW biologists began to pay more attention to stray domestic sheep after their disease threat to bighorns became more prominent and well-recognized in the 1980s. As a result, NDOW learned that a lot more stray domestic sheep roamed the range than they originally thought. During one helicopter deer survey, Benolkin saw bighorns interacting with domestic sheep in the Tobin Range area (Tanner 2012a). Such interaction may have led to a disease outbreak's untimely annihilation of the Tobin Range's desert bighorns.

#### Outbreak Summary

In 1991, a respiratory bacterial infection afflicted the Tobin Range's bighorns (Arthur et al. 1999; Cummings and Stevenson 1995). Anecdotal evidence caused NDOW to conclude that the Tobin bighorn die-off was most likely caused by pneumonia from



domestic sheep (Tanner 2012b). According to Cummings and Stevenson, Tobin bighorns “initiated declines in August 1991 [that] coincided with detection of trespass domestic sheep in bighorn habitat. In July 1994, it was concluded the Tobin population no longer existed” (1995, 79). Ward et al. noted that “only one bighorn was located on this range in January 1992 and none were detected on that range in subsequent surveys” (1997, 553).

In January 1992, as a part of a disease study examining Tobin sheep and those from other Nevada populations, agency researchers captured the last known (at the time) Tobin bighorn via helicopter net-gunning. Personnel also herded trespassing domestic sheep out of the Tobin Range. Biologists collected nose and throat swab samples from the bighorn and domestic sheep and checked them for the presence of pneumonia bacteria. Some pneumonia bacteria (e.g., *Pasteurella trehalosi* and Biotype 3 *M. haemolytica*) were found in samples from the Tobin bighorn and domestic sheep from the Tobin Range (Ward et al. 1997).

Regarding their overall study (which included non-Tobin bighorns), researchers concluded “that transmission could have occurred by nose-to-nose contact of the two sheep species and potentially by aerosols produced if animals coughed or sneezed during periods of intermingling” (Ward et al. 1997, 554). They add:

Potential pathogenic strains of *Pasteurella* spp. in one population of bighorn sheep in which the organisms are indigenous may stimulate protective antibody production in that group of sheep but pose a threat to another population of bighorn sheep when first introduced. This potential should be considered when bighorn populations are being augmented by introducing sheep from other populations such as was done to augment the population on the Tobin Range in 1991. (1997, 555)

Despite the presence of bacteria, signs of illness were not observed in the captured Tobin bighorn. Researchers also did not report carcasses during their study. They stated:

“Therefore, the causes of deaths [in the Tobin Range and the other study areas], believed associated with the loss of these populations, have not been identified” (Ward et al. 1997, 555).

This contradicts the response Cummings and Stevenson filled out in a 1999 questionnaire presented to biologists at the 2<sup>nd</sup> Annual North American Wild Sheep Conference. In response to the question “Have you had a disease die-off in the last 25 years?”, they responded by marking “Yes” and listing “Respiratory bacterial infection – Tobin Range, Pershing County” next to “Cause and herd name” (Arthur et al. 1999). Ward et al.’s population history for the Tobin bighorns (1997) only references one die-off, so the outbreak to which Cummings and Stevenson refer is most likely the same one that occurred in 1991. In a 2009-2010 big game status report, NDOW vaguely states: “For a multitude of reasons, bighorns failed to establish themselves in the Tobin Range” (2010, 59). Ward et al. emphasized that a disease link between wild and domestic sheep was inconclusive in their study because no samples were taken from sheep before mingling (1997). Retired NDOW biologist Jim Jeffress notes that the Tobin disease analysis was performed when wild-domestic sheep disease sampling and monitoring techniques were still in their infancy (2012b).

Despite the Tobin bighorns’ disease-related disappearance, wildlife managers reintroduced bighorns to the Tobin Range in 2003 with 23 animals from central Nevada’s Toquima Range (NDOW 2010; Google Earth 2012). In 2008, this population was augmented with 22 additional Toquima bighorns (NDOW 2010). During a September 2011 survey, 47 bighorns were counted in the Tobin Range (NDOW 2012c). The second reintroduction seems to be a success. However, before biologists attempted their first

reintroduction of desert bighorns to the Tobin Range, they were guided by a variety of policy documents.

### Policy Documents

The BLM's 1982 *Sonoma-Gerlach Management Framework Plan* (Sonoma-Gerlach MFP) covered the Tobin Range during the 1990s outbreak. However, that plan was drafted before a Tobin bighorn population was established in 1984. Nonetheless, the plan considers possible bighorn presence in the future. While desert bighorns ended up being established in the Tobin Range, the BLM plan only mentions California bighorns (BLM 1982).

In the plan, the BLM remarks that "California bighorn sheep are not present in the planning area, but fourteen . . . potential areas for reintroduction have been identified" (BLM 1982, Sec. 46, 79). The Sonoma-Gerlach MFP lists the Tobin Range as potential bighorn habitat and touches on wild-domestic sheep interaction policies (BLM 1982). For example, the BLM states: "Domestic/bighorn sheep conflicts may be a serious problem in some areas. Many of the mountain ranges in the resource area have been identified as potential bighorn sheep habitat. Elimination of domestic sheep use in an area used by bighorns would avoid potential disease and forage competition problems" (Sec. 44, 108).

In explaining its stance regarding prohibition of bighorn reintroduction to active domestic sheep grazing allotments, the BLM notes: "The decision as originally written caused much concern among the sheep permittees of the resource area. They felt that if bighorn sheep were reintroduced into the resource area that the domestic sheep operations would be eliminated. This was never the intention of the original decision" (BLM 1982, Sec. 46, 9).

Another policy document relevant to the Tobin Range bighorn die-off is the BLM's 1989 *Rangewide Plan for Managing Habitat of Desert Bighorn Sheep on Public Lands* (BLM 1989). According to that plan: "In carrying out BLM's responsibilities regarding reintroducing desert bighorn into historic habitats, BLM will be guided by established procedures as recommended by the Desert Bighorn Council [DBC] . . . and by newly accepted practices as they are developed" (BLM 1989, 19). The BLM adds: "For additional guidance on management of desert bighorn habitat, BLM will use established guidance as recommended by the Desert Bighorn Council . . . or subsequent updates" (BLM 1989, 19).

The latest DBC guidelines at the time of the Tobin Range epizootic were its 1990 recommendations in *Guidelines for the Management of Domestic Sheep in the Vicinity of Desert Bighorn Habitat* (DBC Technical Staff 1990). However, while considered, these guidelines did not become BLM advisory policy until 1992 (Brigham, Rominger, and Espinosa T. 2007). Additionally, while the DBC's 1990 guidelines may have delayed or prevented disease, they were released in the year before the Tobin Range's 1991 die-off, and with the slowness of bureaucracies, it is doubtful much could have been done to implement them fast enough to make a difference. Nonetheless, these guidelines existed at the time of the die-off, so they still got plugged into later analysis criteria question answers. Regarding the pre-1990 DBC guidelines and future updates, the BLM notes: "These guidelines will not be used to override management decisions already made through the land-use planning process" (BLM 1989, 19-20). While various guidelines may have smoothed tensions to some extent, the new coexistence of wild and domestic sheep in the Tobin Range sparked conflict and litigation.

### Litigation

Before examining specific Tobin Range policies, it is helpful to provide background on influential litigation focused on bighorn-domestic sheep interaction in the area. This litigation foreshadowed future cases focused on protecting bighorns or retaining domestic sheep grazing rights. According to Tanner, the outcome of the Tobin litigation had a cultural and scientific impact on the bighorn-domestic sheep disease topic. The litigation encouraged research of the disease problem and brought up the issue of range rights vs. privileges (2012a).

In 1986, the Joe Saval Company requested a permit from the BLM that would allow it to graze 175 un-herded domestic sheep in the South Buffalo Allotment on the east side of the Tobin Range (*Joe Saval Co. v. BLM and NDOW* 1991). During the planning process that led to the 1982 Sonoma-Gerlach MFP, at least one portion of this allotment was modified to allow *only* cattle grazing. The modification was part of an effort to prepare the Tobin Range for a future bighorn population (*Joe Saval Co. v. BLM and NDOW* 1991; Tanner 2012a).

In 1987, the BLM District Manager for the Battle Mountain District “approved the application of the Joe Saval Company (Saval) to graze 175 sheep within the Buffalo Valley Allotment, but excluded grazing in the vicinity of Buffalo Ranch and the east side of Mt. Tobin on the basis that such use in those areas was in potential conflict with bighorn sheep” (*Joe Saval Co. v. BLM and NDOW* 1991, 202). These were areas in which Saval wished to run domestic sheep (*Joe Saval Co. v. BLM and NDOW* 1991). In 1988, the BLM Area Manager for the Shoshone-Eureka and Sonoma-Gerlach Resource Areas issued an environmental assessment that considered “the potential conflict between

domestic and bighorn sheep in the western portion of the South Buffalo Allotment, in light of Saval's request to convert its grazing preference in that area from cattle to sheep" (*Joe Saval Co. v. BLM and NDOW* 1991, 203).

In an effort to allow sheep grazing, Saval suggested some possible forms of mitigation that would allow its domestic sheep to coexist with bighorns. The suggestions are listed below.

(1) a health program including vaccination and disease control; (2) a 1-mile buffer zone; (3) sheep-proofing the western allotment boundary by fence construction; and (4) site management practices to provide higher quality water while reducing breeding areas for some insects and disease-causing organisms. Saval also offered to reimburse NDOW for bighorn deaths proven to be caused by the presence of their domestic sheep and to give up use in the Stillwater Range in return for use in the Tobins (Exh. R-11 at 3). (*Joe Saval Co. v. BLM and NDOW* 1991, 203)

The BLM Area Manager rejected Saval's mitigation recommendations and decided not to allow conversion of the western portion of the South Buffalo Allotment from cattle to sheep (*Joe Saval Co. v. BLM and NDOW* 1991). The manager's decision "was based on research indicating that declines and die-offs in bighorn sheep populations were aggravated by disease transmissions from domestic to bighorn sheep when the populations mingled" (*Joe Saval Co. v. BLM and NDOW* 1991, 204).

In 1988, after an environmental assessment was issued, Administrative Law Judge Ramon A. Child presided over an evidentiary hearing focused on the Saval grazing issue. At the hearing, wildlife biologist George Tskuamato of NDOW and veterinarian David A. Jessup of the California Department of Fish and Game (CDFG) stressed the disease threat domestic sheep pose to bighorns. However, Marie Bulgin (of the University of Idaho) and Bobby Rand Hillman (of the Idaho Bureau of Animal Health) stressed that

wild-domestic sheep interaction was not necessarily bad for bighorns' health (*Joe Saval Co. v. BLM and NDOW* 1991).

Despite expert testimony from biologists, Judge Child ruled in favor of the Joe Saval Company: "In his [1989] decision, Judge Child concluded essentially that BLM erred in reserving a portion of the allotment for reintroduction of bighorn sheep, and that the District Manager's limitation of Saval's sheep grazing application was arbitrary and capricious" (*Joe Saval Co. v. BLM and NDOW* 1991, 206). In Judge Child's decision on the issue, he emphasized that bighorns could not be established in areas where domestic sheep grazed, unless all conflicts can be resolved. Judge Child focused on:

. . . the fact that Saval has private holdings within the western portion of the South Buffalo Allotment, Judge Child reasoned that "all conflicts" could not be resolved "without a condemnation proceeding to eliminate appellants' and all private holdings on the potential bighorn sheep habitat on the Tobin Range where that habitat touches allotments wherein active sheep preferences exist" (Decision at 8). Judge Child set aside the District Manager's decision as being contrary to the [1982 Sonoma-Gerlach MFP], and directed BLM to grant Saval's application without restriction. (*Joe Saval Co. v. BLM and NDOW* 1991, 206)

With his ruling, Judge Child directed the BLM to allow Saval to run sheep on the Tobin Range, but the BLM and NDOW appealed the judge's decision (which attempted to remove domestic sheep restrictions put in place to help bighorns). The language in the Sonoma-Gerlach MFP regarding necessity of conflict resolution for bighorn transplants involves *active preference* sheep allotments. According to the decision regarding the Joe Saval Co. v. BLM and NDOW: "The portion of the MFP relied on by Judge Child stated that '[b]ighorn sheep will not be reintroduced on active preference sheep allotments unless all conflicts can be resolved'" (1991, 207).

According to the BLM, "active preference" refers to "that portion of the total grazing preference for which grazing use may be authorized" (2005). All of Saval's use

of the South Buffalo Allotment since 1978 had been with cattle, which were the active livestock preference on the allotment. Saval's "sheep use [had] shifted from active preference to exchange-of-use" (*Joe Saval Co. v. BLM and NDOW* 1991, 207). The South Buffalo Allotment was no longer an active preference sheep allotment because Saval had exchanged sheep use for cattle use. Thus, with the allotment not being an active preference sheep allotment, conflict mitigation was a more important deciding factor than conflict resolution. Conflict mitigation could not be achieved, and the BLM acted in accordance with the Sonoma-Gerlach MFP with its 1987 decision. So, in a 1991 decision, the Interior Board of Land Appeals (IBLA) reversed Judge Child's decision and upheld the BLM's domestic sheep restrictions in the Tobin Range (*Joe Saval Co. v. BLM and NDOW* 1991).

The 1991 IBLA decision states that "a preponderance of documentary and oral evidence supports the wisdom of [wild-domestic sheep separation]" (*Joe Saval Co. v. BLM and NDOW* 1991, 208). It goes on to remark:

No significant challenges, in terms of contrary scientific findings, were put forward to impugn the conclusions of the Goodson paper and the Jessup articles. At the hearing, the thrust of the Saval evidence on conflict between the two species was to review and critique, not contradict, the evidence presented by BLM and NDOW. The record fully supports the action taken by BLM and Saval has failed to meet its burden of proving otherwise, or of showing that its grazing rights have been injured. Therefore, in the grazing application under appeal, BLM properly restricted the western third of the allotment in the interest of the potential reintroduction of bighorn sheep. (*Joe Saval Co. v. BLM and NDOW* 1991, 208-209)

Now that an overview has been presented on the Tobin Range's 1991 desert bighorn disease outbreak and related factors, it is time to analyze some specific policies that could have prevented or worsened that outbreak. These policies are analyzed by looking at questions that compose nine policy analysis criteria.



## POLICY ANALYSIS CRITERIA

### **1.) *Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?***

#### *Answer and Explanation*

Clear buffer zones were not in place (Tanner 2012a). At the time of the establishment of the Tobin bighorn population in 1984, wildlife managers still poorly understood the biology of the wild-domestic sheep disease problem. The transmission mechanism was not yet clearly comprehended, and the role of nose-to-nose contact was not yet recognized. In the early years of transplants, biologists also did not know the extent of wild or domestic sheep movements very well. Additionally, in the early 1980s, NDOW biologists did not know just how many stray domestic sheep were left in the field after the grazing season was over (Tanner 2012a).

#### *Policy*

The DBC's 1990 guidelines state: "No domestic sheep grazing should be authorized or allowed within buffer strips  $\geq 13.5$  km [8.4 mi] wide surrounding desert bighorn habitat, except where topographic features or other barriers prevent any interaction" (DBC Technical Staff 1990, 34). NDOW's 1978 desert bighorn biological bulletin recommends that "grazing by domestic sheep should not be allowed in any areas occupied by desert bighorn sheep during any time of the year" (NDFG 1978, 73).

### **2.) *Were special supervision rules in place for sheepherders?***

#### *Answer and Explanation*

Supervision rules were not in place for the same reason buffers were not in place. Wildlife managers still had an incomplete understanding of the wild-domestic sheep disease issue (Tanner 2012a).

### Policy

The DBC's 1990 guidelines recommend that: "Domestic sheep that are trailed or grazed outside [a] 13.5-km [8.4-mi] buffer, but in the vicinity of desert bighorn ranges, should be closely supervised by competent, capable, and informed herders" (DBC Technical Staff 1990, 34).

### **3.) *Were domestic sheep trailing restrictions in place to ensure separation?***

#### Answer and Explanation

Trailing restrictions were not in place because wildlife biologists still did not fully understand the bighorn-domestic sheep disease problem (Tanner 2012a). Also, according to Tanner, in Nevada, some domestic sheep grazing permittees did not and still do not want the BLM to know where and when they trail their sheep. Cultural factors explain this. Sheep grazers have had a tendency to resist being controlled by the federal government, and they have embraced the Sagebrush Rebellion mindset (Tanner 2012a).

### Policy

The DBC's 1990 guidelines recommend that: "Domestic sheep should be trucked rather than trailed, when trailing would bring sheep closer than 13.5 km [8.4 mi] to bighorn range. Trailing should never occur when domestic ewes are in estrus" (DBC Technical Staff 1990, 35).

### **4.) *Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?***

#### Answer and Implementation

Before desert bighorns were reintroduced to the Tobin Range, wildlife and land managers directly considered the presence of domestic sheep (BLM 1982; DBC Technical Staff 1990; Jeffress 2012a; Tanner 2012a). After planning, NDOW got

clearance from the BLM to release bighorns into the Tobin Range. It got such clearance from the planning process that produced the 1982 Sonoma-Gerlach MFP. The NDOW made a special effort to “clear” transplant sites before reintroducing bighorns. This means it got BLM approval decisions and documents in place before reestablishing wild sheep populations (Tanner 2012a).

### Policy

Prior to the 1984 reintroduction of bighorns to the Tobin Range, there was an internal NDOW policy not to release bighorns into areas with domestic sheep (Tanner 2012a). Also, according to the BLM’s 1982 Sonoma-Gerlach MFP, “bighorn sheep will not be reintroduced on active preference sheep allotments unless all conflicts can be resolved. The domestic sheep permit will remain transferable as a sheep permit. Established, permitted sheep trailing routes will be considered in the same sense as active preference sheep allotments” (BLM 1982, Sec. 46, 8). Additionally, the DBC’s 1990 guidelines state: “Bighorn sheep should not be reintroduced into areas where domestic sheep have grazed during the previous 4 years” (DBC Technical Staff 1990, 35).

***5.) Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?***

### Answer and Implementation

Grazing allotment alteration occurred in the Tobin Range before the 1984 desert bighorn reintroduction occurred (Tanner 2012a). During the planning process that led to the 1982 Sonoma-Gerlach MFP, a portion of an allotment in the Tobin Range area that could be used for cattle or sheep was basically locked into use by cattle (Tanner 2012a; *Joe Saval Co. v. BLM and NDOW* 1991). It could not be modified to allow sheep grazing

again. When bighorns were transplanted to the Tobin Range, only cattle grazed on the allotment (Tanner 2012a).

### Policy

Range Policy from the BLM's 1982 Sonoma-Gerlach MFP states: "Allow for conversion from cattle to sheep on all allotments within the resource area except where conflicts with bighorn sheep would occur" (BLM 1982, Sec. 44, 110). The plan adds: "Allow for conversion from sheep to cattle on a case-by-case basis. Conversion ratio and authorization will depend upon the suitability of the rangeland involved and will be made only where cattle can be adequately controlled and managed" (BLM 1982, Sec. 44, 110).

### ***6.) Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?***

### Answer and Implementation

Various forms of negotiation occurred during litigation that ran through the 1980s and 1990s (Tanner 2012a; *Joe Saval Co. v. BLM and NDOW* 1991). See the "Litigation" commentary that starts on page 98 earlier in this section for more information. In Nevada, certified letters were also sent to all livestock permittees (including non-sheep operators) in areas that could potentially be affected by particular bighorn transplant efforts (Tanner 2012b).

### Policy

Due to accelerated bighorn reintroduction efforts in Nevada, the livestock industry in the state viewed NDOW's wild sheep transplant program as a significant threat. So, in the 1980s, the Nevada Wildlife Commission passed a policy requiring NDOW to formally notify (through certified mail) livestock operators of bighorn reintroduction plans that would take place in their grazing areas (Tanner 2012a). Sending

out letters was a political action to dispel some locals' perceptions that NDOW's bighorn program was operated with secrecy (Tanner 2012b).

***7.) If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?***

*Answer and Explanation*

Bighorns that got near domestic sheep were not removed from the wild in the Tobin Range. After domestic sheep contact had been detected, the Tobin bighorns did not survive long enough for fatal removal to cause any benefit (Tanner 2012b).

*Policy*

Lethal bighorn removal was not really considered an option for NDOW until fairly recently (within the last five to six years) (Dobel 2012a).

***8.) Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?***

*Answer and Nature*

The NDOW and the BLM heavily coordinated communication and activities regarding the issue of domestic sheep disease possibly being a problem for bighorns in the Tobin Range. As discussed earlier, NDOW worked directly with the BLM to clear the Tobin Range in preparation for establishing bighorns there (Tanner 2012a).

There was good cooperation between NDOW and the BLM regarding the establishment and management of the Tobin bighorn population. The BLM and NDOW encountered opposition from the State Department of Agriculture at a statewide level. However, this happened after the Tobin die-off and was not an issue in the Tobin Range. The Tobin transplant happened too early for the disease issue to be prominent enough to cause major opposition from the State Department of Agriculture (Tanner 2012b).

In the 1990s, tension existed at the state level. In the answers to a questionnaire presented to biologists at the 2nd North American Wild Sheep Conference in 1999 (Table 2.1 on page 52), Cummings and Stevenson elaborate on state-federal relationship challenges regarding desert bighorn management in Nevada. Many of the general topics they address could apply to bighorn-domestic sheep interaction policy:

Federal land management agencies tend to have many conflicting objectives and plans. The schizophrenic nature of multiple use agencies is often the root of unnecessary delays relative to obtaining required clearances and permits for wild sheep projects.

Wildlife programs and concerns within the federal land management agencies ordinarily do not extend much beyond feral horses and burros, and species which are federally listed as threatened or endangered. Consequently, the welfare of wild sheep populations and management of wild sheep habitat often receives little consideration. Moreover, management actions within the scope of feral horses and burros, and threatened and endangered species usually have profound impacts on bighorn sheep habitat, distribution, and movements.

The high turn-over rate of personnel from Washington to the field ensures many federal employees lack background knowledge on critical issues, and lack intimate knowledge of resources under their responsibility. In short, brief tenure breeds unfamiliarity on many levels, and ultimately serves to delay issuance of essential clearances and permits for desert bighorn sheep projects and activities. (Arthur et al. 1999, 451-452)

***9.) Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?***

Funding difficulties pertaining to the management of bighorn-domestic sheep interaction were not an issue in the Tobin Range (Tanner 2012b).

**Policy Efficacy Summary**

Regarding wild-domestic sheep interaction in the Tobin Range before its bighorn disease outbreak, some policies were missing, some logical policies were in place, and implementation was often ineffective. Clear buffers, special supervision rules for sheepherders, and trailing restrictions were not in place (Tanner 2012a). The absence of these policies contributed to the Tobin Range's bighorn die-off. Nonetheless, domestic

sheep presence was considered before bighorn reintroduction, grazing allotment alteration occurred, and negotiation and education took place (BLM 1982; Tanner 2012a). The implementation of these policies probably helped delay the die-off of bighorns in the Tobin Range, which indicates some policy efficacy. However, though part of an allotment was restricted (*Joe Saval Co. v. BLM and NDOW* 1991), domestic sheep still existed in the Tobin Range (Ward et al. 1997) and were not sufficiently managed to prevent disease. Also, negotiation proved largely ineffective because a local sheep producer was hostile enough to initiate litigation (*Joe Saval Co. v. BLM and NDOW* 1991) and did not manage domestic sheep in a manner that prevented interaction.

In the Tobin Range, bighorns near domestic sheep were also not removed (Tanner 2012b). Not removing bighorns seen interacting with domestic sheep could have been a mistake, though one wonders if this would have done much good without concurrent strengthening of other policies. For the Tobin Range, agency coordination also took place, and interagency tension and funding were not major problems (Tanner 2012a, b). Despite what seemed to be sincere, logical coordination between agencies (e.g., the BLM and NDOW teamed up to defend themselves against sheep rancher litigation in *Joe Saval Co. v. BLM and NDOW* 1991), this coordination could have been more effective because it still did not improve policies enough to prevent disease.

## **SECTION 2 – ALDRICH MOUNTAIN, OREGON: 1991**

### **Introduction**

Aldrich Mountain (44° 22' 35.54"N, 119° 27' 3.03"W) is located in eastern Oregon's Aldrich *Mountains* in western Grant County. The mountain is about 40 km (25 mi) west of John Day (Google Earth 2012). Aldrich Mountain primarily lies in the Malheur National Forest with its western slopes stretching into lands that are private, BLM-managed, or owned by the Oregon Department of Fish and Wildlife (ODFW). The western portion of Aldrich bighorn range borders the Ochoco National Forest (Google Earth 2012; USFS 2012c). According to the BLM's 1995 mountain sheep ecosystem management strategy, the Aldrich Mountain bighorn habitat bioregion is 52 percent BLM land, 24 percent other federal land, 15 percent state land, and 9 percent private land (BLM 1995).

As of 2012, most of Aldrich Mountain's bighorn range occurred along the mountain's steep, barren western slopes on BLM land and ODFW land in the Phillip W. Schneider Wildlife Area (Google Earth 2012; USFS 2012c; ODFW 2006). At the time of the Aldrich Mountain die-off, the Phillip W. Schneider Wildlife Area was known as the Murderers Creek Wildlife Area (ODFW 2006).

The USFS analyzed roadless portions of the Aldrich Mountain region as part of a study for potential wilderness designation. In a report, the USFS describes the Aldrich Mountain area's topography and vegetation:

The terrain is extremely varied and primarily consists of steep and broken slopes on the west and south, and steep bench slopes to the north. In Smokey, Oliver, and Jackass Creeks the dominant peaks are Aldrich and Little Aldrich Mountains. Elevations range from 6,950 feet below the crest of Aldrich Mountain to less than 4,350 feet on Aldrich Creek.





Figure 4.3. Aldrich Mountain terrain.



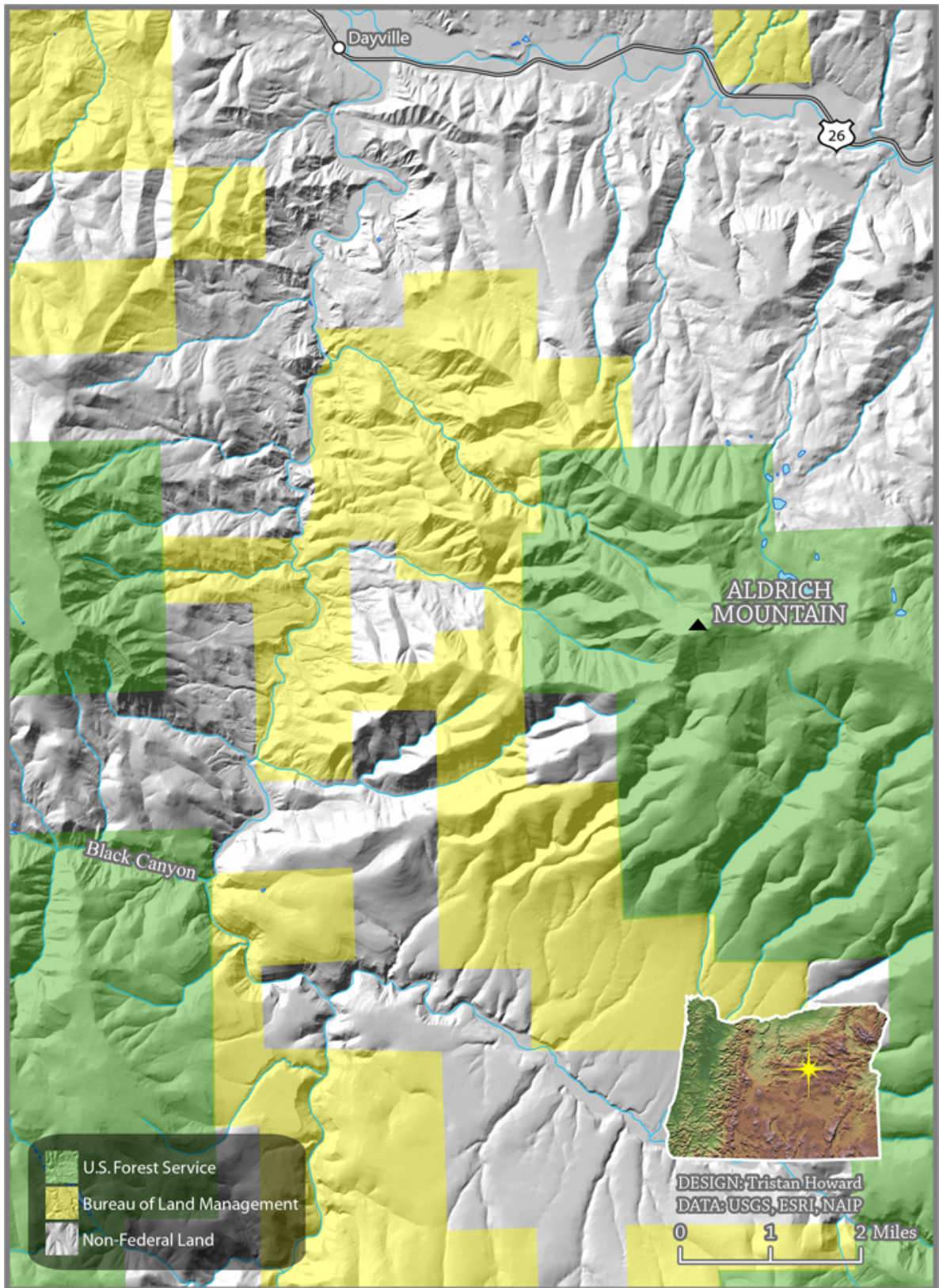


Figure 4.4 Aldrich Mountain federal land ownership.

The Aldrich Mountain area is approximately 40 percent forested. Vegetation on the forested west- and south-facing slopes is predominantly ponderosa pine with Douglas-fir and grand fir understories. The ground cover includes elk sedge, pinegrass, and wheatgrass. The forested areas north of Aldrich Mountain are primarily grand fir, Douglas-fir, western larch, and lodgepole pine, with a ground cover of huckleberry, pinegrass and brome grasses. The highest elevations are occupied by subalpine fir and/or alpine sage and other subalpine shrubs and grasses. The drier or nonforested sites [bighorn habitat] on all aspects are vegetated with juniper, sagebrushes, mountain-mahogany, and some scattered ponderosa pine. Ground cover on these sites includes wheat grasses, fescue, and bluegrass. This area has about 1,300 forested acres that meet the Pacific Northwest Region's definition of old growth. (USFS 2010a, 2)

California bighorns were reintroduced to Aldrich Mountain in 1978 (ODFW 2003). In 1988 and 1989, hundreds of domestic sheep were authorized to graze on a USFS allotment west of Aldrich Mountain (USFS 1988, 1989a). In 1991, a pneumonia outbreak likely caused by domestic sheep reduced the Aldrich Mountain bighorn population by about 70 percent (ODFW 2003). Policy documents related to the Aldrich Mountain wild-domestic sheep situation were Oregon's 1986 bighorn management plan, a 1984 BLM land and resource management plan, and a 1990 USFS plan (ODFW 1986; BLM 1984; USFS 1990b).

As for bighorn-domestic sheep interaction policies in general, Aldrich Mountain lacked buffers, shepherd supervision rules, and sheep trailing restrictions (Foster 2012; BLM 1988, 1989a). However, managers considered the presence of domestic sheep before reintroducing wild sheep in 1978, and grazing alteration efforts likely occurred (ODFW 1986; Foster 2012). Based on the research performed for this project, it is unknown if negotiation or education was implemented regarding the bighorn-domestic sheep disease issue. It is also unknown if bighorns near domestic sheep were removed from the wild on Aldrich Mountain. However, agency coordination occurred, and tension was likely. Additionally, it is unknown if managers of the Aldrich Mountain bighorns

faced funding difficulties in their efforts to separate them from domestic sheep (Foster 2012). To gain a fuller understanding of these policies and policy absences, it helps to provide background on Aldrich Mountain's California bighorns before they were affected by disease beginning in 1991.

#### *Bighorn Population History Prior to Outbreak*

In 1978, wildlife managers reintroduced California bighorns to Aldrich Mountain with a transplant of 14 animals from southeastern Oregon's Hart Mountain National Antelope Refuge. In 1981, the Aldrich bighorn population was augmented with four additional bighorns from Hart Mountain (ODFW 2003). In 1990, about 85 bighorns lived on Aldrich Mountain, but by the late 1980s, they shared their range with hundreds of domestic sheep (USFS 1988, 1989a, 1990).

#### *Nearby Domestic Sheep*

In 1991, the BLM only permitted cattle grazing in the Aldrich Mountain area (Rodgers 2012). However, in the early 1990s, the Ochoco National Forest's Bearskull-Cottonwood grazing allotment existed within five miles of Aldrich bighorn range (ODFW 2003; Reeves 2012). The allotment was near Black Canyon, which helps explain why ODFW biologist Craig Foster referred to it as the "Black Canyon domestic allotment" as discussed later in this analysis (Reeves 2012; Foster 2012). The Ochoco National Forest's 1989 *Land and Resource Management Plan* reveals that 900 domestic sheep were once permitted to graze on that allotment (USFS 1989b). An examination of the 1991 annual operating instructions (AOIs) for the Bearskull-Cottonwood Allotment reveals that 900 domestic sheep could have been authorized to graze on the allotment in

1991, but the only authorized grazing that year was done by 50 cattle. The 1991 allotment users applied for non-use regarding their sheep grazing privileges (USFS 1991).

Steve Gibson (Rangeland Program Manager for the Ochoco National Forest) stated: “According to a very brief review of my records (AOIs) the last time sheep grazed on the allotment was in 1989” (2012). In 1989, 600 domestic sheep were authorized to graze on the allotment from June 16 to September 15 (USFS 1989a). According to the 1989 annual operating instructions: “Livestock numbers for this season will be 600 head of sheep and 80 head of cattle” (USFS 1989a, 1). In 1988, allotment users also requested and got permission to graze 600 domestic sheep on the Bearskull-Cottonwood Allotment (USFS 1988). With so many domestic sheep in the area in the years preceding the Aldrich Mountain die-off, it is possible that strays may have remained on the range and contributed to the 1991 disease outbreak.

#### Outbreak Summary

In 1991, bighorns at Aldrich Mountain experienced a pneumonia outbreak.

According to ODFW, the Aldrich Mountain bighorns:

. . . abruptly declined from 100 animals to 32 animals. The cause was unknown at the time, but pneumonia was suspected. Subsequent information indicated pneumonia caused the decline. No definitive evidence as to what caused the pneumonia outbreak was found. However, trailing practices on an open range domestic sheep allotment within 5 miles of this bighorn herd were altered in 1993, and to date, no other die-offs have occurred. (2003, 61)

The ODFW adds that “a change in trailing practices to keep domestic sheep approximately 5 miles away from [Aldrich Mountain] wild sheep in the spring and 20 miles in the fall has been adequate” (2003, 60). In reference to the Aldrich Mountain die-off and others, ODFW states: “Contact with domestic sheep or goats is the most likely source for these outbreaks” (2003, 61). By 2012, an estimated 120 bighorns occurred at

Aldrich Mountain (ODFW 2012). Though Aldrich Mountain bighorns have recovered from their 1991 die-off, a variety of policy documents shed light on just how conscientious local land managers were of a domestic sheep disease threat.

### Policy Documents

One of the most applicable policy documents in place at the time of the 1991 Aldrich Mountain die-off was Oregon's 1986 bighorn management plan. It clearly acknowledges the disease problem by stating: "Parasites and diseases, especially those transmitted from domestic sheep, can be devastating to bighorn sheep" (ODFW 1986, 7). Via its included comment letters, this plan also provides a snapshot of how prominent the wild-domestic sheep issue was in Oregon in the late 1980s. For example, a letter by Allan R. Polenz of the Oregon Hunter's Association recommended that ODFW have: "Strict enforcement of assurances that domestic sheep and bighorn sheep be kept separated, and that bighorn sheep not range where the domestic sheep have been" (ODFW 1986, A-3).

The BLM's 1984 *Proposed John Day Resource Management Plan and Final Environmental Impact Statement* covered Aldrich bighorn range during the time of the die-off. However, it mainly references bighorns in the context of forage availability and animal unit months (AUMs). It does not address wild-domestic sheep interaction policy (BLM 1984).

The Ochoco National Forest is in the vicinity of the western edge of Aldrich Mountain bighorn range (USFS 2012c). An examination of the 1989 land and resource management plan for that Forest reveals that it hosted domestic sheep allotments. However, the plan makes no reference to wild-domestic sheep interaction policy (USFS 1989b).

The 1990 *Malheur National Forest Land and Resource Management Plan* directly addresses the wild-domestic sheep disease issue with a provision about not putting domestic sheep in bighorn range (USFS 1990b). Its description of a forest-wide standard states: “Do not stock livestock allotment pastures within bighorn sheep range with domestic sheep” (USFS 1990b, IV-31). According to natural resources policy expert Martin Nie, “the only component of national forest planning, other than viability, that is binding and enforceable on the agency is a planning *standard*” (April 26, 2013, e-mail message to author). Thus, the fact that the domestic sheep threat was acknowledged in an actual standard is significant.

The final environmental impact statement (FEIS) for the Malheur Forest plan lists California bighorns as a sensitive species (USFS 1990a). As part of management direction common to all plan alternatives, the FEIS states: “The habitat on Aldrich Mountain . . . will be maintained for California bighorn sheep” (USFS 1990a, II-32). While these are solid provisions, one must keep in mind that they were published in a 1990 plan, and the Aldrich Mountain die-off happened soon after in 1991. While in existence at the time of the disease outbreak, these USFS regulations may not have been well-known or feasible to enforce because of how recently they were published.

The BLM’s 1990 guidelines for domestic sheep management in desert bighorn habitat would have been relevant at the time and could apply to any bighorn subspecies (DBC Technical Staff 1990). However, Aldrich Mountain’s wild sheep are California bighorns, so the 1990 BLM guidelines are not included in the analysis criteria answers below.

Now that Aldrich Mountain's 1991 California bighorn disease outbreak and related factors have been summarized, useful context has been established for analyzing specific policies. These policies are analyzed by addressing questions that make up nine policy analysis criteria.

#### POLICY ANALYSIS CRITERIA

***1.) Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?***

*Answer and Explanation*

Before the die-off, no clearly defined buffer zones existed in the Aldrich Mountain area. According to ODFW biologist Craig Foster: "As I understood it at the time we had asked for this or a change in livestock class but the Ochoco Forest had not acted" (Foster 2012).

***2.) Were special supervision rules in place for sheepherders?***

*Answer and Explanation*

Regarding potential interaction with bighorns, no special sheepherder supervision rules were discovered in the USFS's 1988 and 1989 annual operating instructions for the Bearskull-Cottonwood Allotment. Minimal sheep herding guidelines were provided in these instructions, but they focused on grazing locations (especially riparian areas) and durations with no reference to bighorns (BLM 1988, 1989a). When asked, Foster's response to the question above was: "No, No clue" (2012).

***3.) Were domestic sheep trailing restrictions in place to ensure separation?***

*Answer and Explanation*

Trailing restrictions were not in place before the die-off, but they were put in place afterward (Foster 2012).



***4.) Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?***

Answer

According to Foster, domestic sheep were a consideration when the Aldrich bighorn population was established (2012). However, while doing research for this study, such consideration was only found in print as early as the 1980s.

Policy

Oregon's 1986 bighorn management plan states: "Bighorn sheep will not be introduced into locations where they may be expected to come into contact with domestic sheep" (ODFW 1986, 7). According to Foster: "ODFW has a policy to not re-introduce bighorn where there may be domestic conflict. That was formalized in the mid 90's to be a 9 mile buffer. [The] Aldrich herd was re-established . . . when the Black Canyon domestic allotment was vacant" (2012). An attachment to Oregon's 1986 bighorn plan touches on domestic sheep presence consideration. A letter from Ralph Denny (president of the Oregon Woolgrowers Association) emphasizes a desire by sheep producers to not lose grazing land access because of the establishment of new bighorn populations. In an ODFW response letter, Monte Montgomery remarks:

Though several historic mountain sheep ranges have been identified as having existing domestic sheep allotments, they are identified as transplant sites, but are very low on the priority. Introductions would not be made into areas where there would be any potential of removing domestic sheep for the purpose of reintroduction. The thought in identifying those areas was that future consideration for introduction would be eliminated, unless changes in ownership or land use were brought about for other regions. We would hesitate to put wild sheep on any range that had domestic sheep in the past 20 years. (ODFW 1986, A-5)

***5.) Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?***

***Answer and Explanation***

According to Foster: “As I understood it at the time we had asked for . . . a change in livestock class but the Ochoco Forest had not acted” (2012). So, an attempt to convert the allotment to cattle may have occurred.

***Policy***

Oregon’s 1986 bighorn plan lists a management strategy to: “Work with land management agencies in an effort to locate domestic sheep grazing allotments away from identified (present/future) bighorn sheep ranges” (ODFW 1986, 7).

***6.) Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?***

***Answer and Implementation***

Foster’s response to the above question was: “No idea” (2012). However, at the state level, ODFW sent its 1986 bighorn management plan (includes info on wild-domestic sheep separation) to the Oregon Sheep Growers Association, other agricultural stakeholders, hunting groups, and environmental groups (ODFW 1986).

***Policy***

Regarding the establishment of new bighorn populations, according to Oregon’s 1986 bighorn management plan: “Cooperative agreements that ensure bighorn sheep habitat integrity of the release sites must be enacted” (ODFW 1986, 9). A key part of ensuring habitat integrity is to separate wild and domestic sheep, so this clause qualifies as policy applicable to negotiation and education efforts related to the disease issue.

***7.) If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?***

*Answer*

When asked the above question, Foster was not sure if bighorns that got near domestic sheep were ever removed from the wild in the Aldrich Mountain area (2012).

*Policy*

Removing bighorns near domestic sheep was ODFW district policy in the area by 1995. Foster worked with Aldrich bighorns starting that year, and he was not sure if bighorn removal was the policy earlier than 1995 (2012).

***8.) Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?***

*Answer and Nature*

According to Foster: “As I understood it at the time we had asked for . . . a change in livestock class but the Ochoco Forest had not acted” (2012). So, there was likely some coordination and possibly tension between ODFW and the USFS. Some agency tension may have also existed at the state level during the time of the outbreak. In the answers to a questionnaire presented to biologists at the 2nd North American Wild Sheep Conference in 1999 (Table 2.1 on page 52), ODFW biologist Don Whittaker listed “domestic sheep allotment management” as a state-federal relationship challenge involved with management of California bighorn sheep (Arthur et al. 1999, 437).

*Policy*

Oregon’s 1986 bighorn management plan lists the management strategy of: “Work with land management agencies to insure no contact between established bighorn sheep herds and domestic sheep” (ODFW 1986, 7).

***9.) Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?***

**Answer**

When asked the above question, Foster had no idea if ODFW encountered funding difficulties related to Aldrich Mountain wild-domestic sheep interaction management (2012).

**Policy Efficacy Summary**

Bighorn-domestic sheep interaction policy in the Aldrich Mountain area before its die-off was not prominent or especially effective. A lack of clear buffers, sheepherder supervision rules, and trailing restrictions (Foster 2012) demonstrate notable policy gaps. The consideration of domestic sheep before reintroducing bighorns to Aldrich Mountain (Foster 2012) may have delayed the onset of disease because bighorns were reintroduced when a nearby sheep allotment was vacant. Nonetheless, neglecting to consider domestic sheep after reintroduction demonstrates more missing policy. Grazing alteration efforts did not happen fast enough or effectively enough to prevent the 1991 disease outbreak, but according to ODFW, they proved to be effective afterward (2003). Details regarding education/negotiation, bighorn removal, agency coordination/tension, and funding difficulties for Aldrich Mountain are unclear.

### **SECTION 3 – HIGHLAND/PIONEER MOUNTAINS, MONTANA: 1994-1995**

#### **Introduction**

The Highland and Pioneer Mountains are located in southwest Montana. The Highland Mountains (45° 44' 8.48"N, 112° 30' 1.72"W) are about 32 km (20 mi) south of Butte and Interstate 90 and primarily lie in Silver Bow and Madison Counties (Google Earth 2012). They are situated along the Continental Divide and Beaverhead Valley. Steep, tree-covered slopes form the majority of the Highland Mountains, and the range features a few peaks higher than 3,048 m (10,000 ft) (Reese 1985).

To the southwest, The Beaverhead Valley, Big Hole River, and Interstate 15 separate the Highland Mountains from the Pioneer Mountains, which are in Beaverhead County and about 40 km (25 mi) south of Butte (Google Earth 2012; Reese 1985; MFWP 2010a). The Pioneer Mountains (45° 28' 59.79"N, 112° 57' 57.59"W) consist of the West Pioneers (gentler and not primary bighorn habitat) and the East Pioneers, which host bighorns and 3,353-meter (11,000-foot) peaks (Reese 1985; MFWP 2010a). According to Reese: "The East Pioneers are a long, narrow stretch of high alpine peaks surrounded by lower forested foothills" (1985, 29). Bighorns in the Highland and Pioneer Mountains intermix. According to the Montana Department of Fish, Wildlife, and Parks (MFWP), "on numerous occasions, bighorn sheep rams have been observed crossing Interstate 15 between the Highland and East Pioneer mountain ranges" (2010a, 203).

According to the BLM's 1995 mountain sheep ecosystem management strategy, 44 percent of the "Pioneers and Highland Mtns" bighorn habitat bioregion is BLM land, 32 percent is other federal land (Beaverhead-Deerlodge National Forest), 4 percent is



Figure 4.5. Highland/Pioneer Mountains terrain.



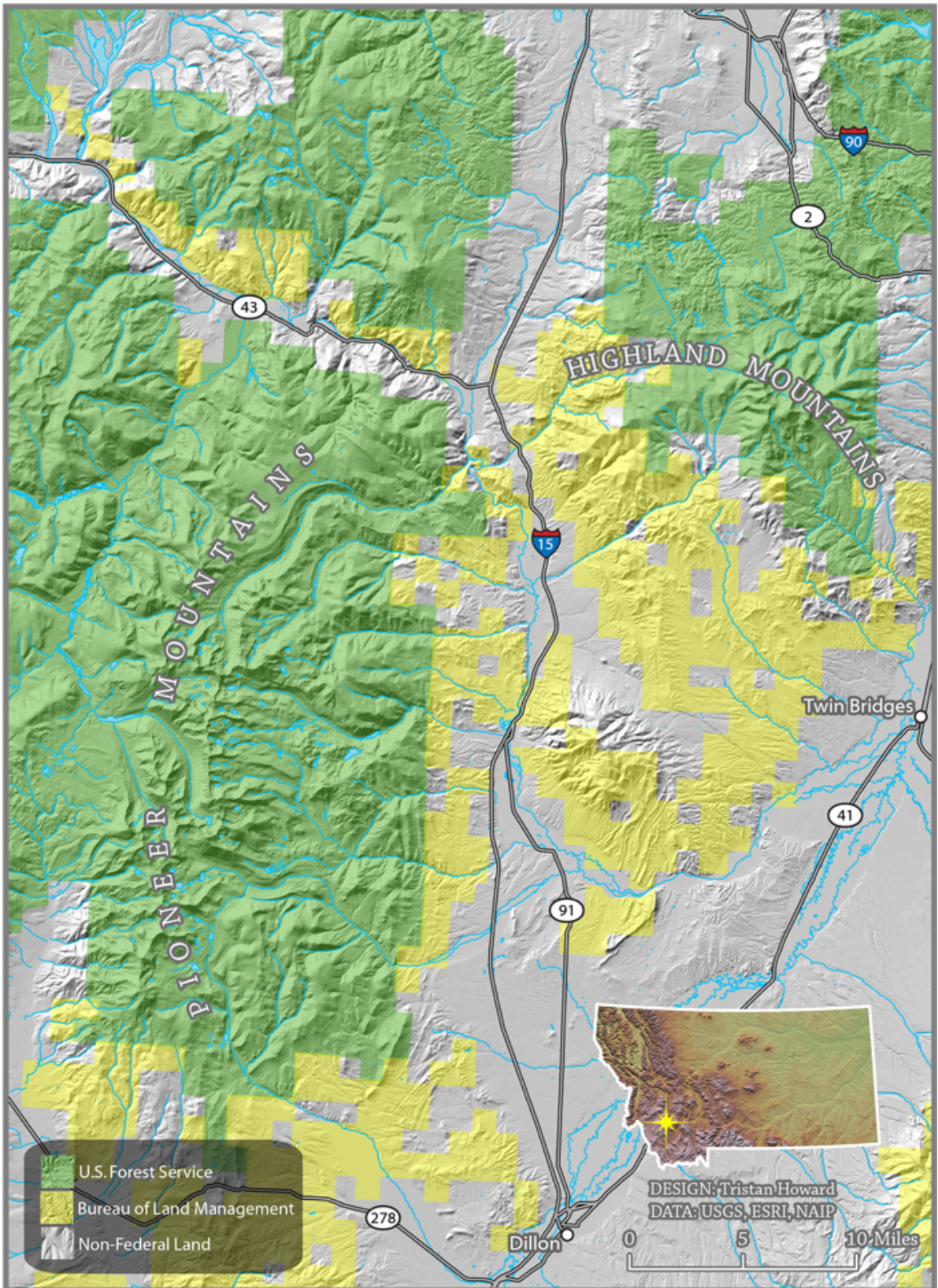


Figure 4.6. Highland/Pioneer Mountains federal land ownership.

state land (managed by the Department of Natural Resources and Conservation), and 20 percent is private land (BLM 1995; MFWP 2010a). Highland/Pioneer bighorn range is within state Bighorn Hunting District 340 (Highland District) (MFWP 2010a). The MFWP provides a description of the biophysical geography and land ownership found in this bighorn range:

The Highland area . . . includes the Highland Mountains and the northern portion of the East Pioneer Mountains near the town of Melrose . . . . The district is comprised of shrub grasslands (sagebrush, mountain mahogany, bluebunch wheatgrass, Idaho fescue), coniferous forests, and agricultural lands . . . . The majority of private land is in agricultural production, primarily cattle although there are several hobby sheep farms as well. . . .

Approximately 233 mi<sup>2</sup> of the district . . . is currently occupied by bighorn sheep during some portion of the year . . . . Bighorn sheep winter range comprises approximately 188 mi<sup>2</sup> of this district (16%); 23% is private land and 77% public, with the majority of public land being administered by the BLM. Based on past and current telemetry data and recent observations, the majority of the bighorn sheep population winters on public lands.

The vegetation within the occupied bighorn sheep range is predominantly rocky terrain interspersed with sagebrush grassland, mountain mahogany, and lodgepole pine and Douglas fir forest. (MFWP 2010a, 202)

Wildlife managers reintroduced Rocky Mountain bighorns to the Highland and Pioneer Mountains in 1967. Highland/Pioneer bighorns shared their range with private land domestic sheep for decades before a 1994-1995 pneumonia outbreak contributed to reducing their numbers by 87 percent (Aune et al. 1998; Arthur et al 1998). Aside from MFWP's management plan, no policy documents directly related to the Highland/Pioneer bighorn-domestic sheep situation were discovered, partly because no public land sheep grazing allotments exist in the area (MFWP 2010a).

In the realm of wild-domestic sheep interaction policies, the Highland and Pioneer Mountains lacked clear buffers between bighorns and domestic sheep (Frisina 2012). Special sheepherder supervision rules, trailing restrictions, and grazing allotment



alteration efforts were not applicable because the Highland and Pioneer Mountains had no domestic sheep grazing allotments (MFWP 2010a). Domestic sheep presence was not considered before reintroduction. However, negotiation and education with local domestic sheep owners was attempted before the Highland/Pioneer outbreak. Bighorns that got near domestic sheep were most likely not removed from the wild. Agency coordination occurred with some possible tension, and funding difficulties were not an issue for bighorn-domestic sheep interaction management in the Highland and Pioneer Mountains (Frisina 2012). To better understand interaction policies that impacted the Highland/Pioneer bighorns, it helps to examine their population history before disease struck them.

#### *Bighorn Population History Prior to Outbreak*

Rocky Mountain bighorns in the Highland/Pioneer population originally occurred in both the Highland Mountains and East Pioneer Mountains (Hoar, Worley, and Aune 1996). However, the Highland/Pioneer population is often just referred to as the Highlands population (MFWP 2010a; Arthur et al. 1999; Hoar, Worley, and Aune 1996). The Highland/Pioneer bighorn population has a history of special local importance. The MFWP remarks:

Bighorn sheep in the Highlands herd have been one of Montana's best-known and premier wild sheep herds, both for hunting and wildlife watching. Because much of the annual range is within easy access and sight of Interstate 15 and several secondary roads, going out to "watch sheep" has been and continues to be a popular pastime of many local residents and wild sheep fans. (2010a, 204)

The MFWP adds: "Second only to the Missouri Breaks herd in Montana for trophy status, the Highlands herd at one time was known as one of the best places to harvest a trophy ram" (2010a, 204).

Over-hunting and livestock disease helped wipe out the original Highland/Pioneer bighorns in the early 1900s (MFWP 2010a). Aune et al. provide more history:

[Bighorns] were reintroduced to the area in 1967 when 27 sheep were transplanted from the Sun River. The initial transplant population was supplemented with 31 sheep in 1969. The population expanded in size and range up through the mid 1990's so that sheep today [in 1998] extend across the Big Hole River and into the foothills of the Pioneer Mountains. The number of males in the population grew and the herd became well known for its trophy quality rams. The number of sheep was estimated [to be] 350-400. Harvests were increased in 1992 and 1993 to 39 and 40 sheep. In addition, 35 sheep were captured and transplanted from the population in 1992 to reduce sheep numbers. In 1993 the population was at an all time high. (1998, 50)

About 400 bighorns may have existed at the peak of the population, and over 300 were seen in the early 1990s. According to MFWP, "it was not uncommon for groups of 50 or more rams to be observed" (2010a, 204). Such high numbers of bighorns increased the likelihood of interaction with domestic sheep.

#### Nearby Domestic Sheep

Regarding the Highland/Pioneer population, Aune et al. remark that "bighorn sheep from this herd unit shared habitat with domestic sheep during all seasons" (1998, 57). They add: "Domestic sheep and bighorns coexisted in the Highlands-Pioneers for nearly 20 years before a pneumonia outbreak" (1998, 64). The MFWP provides more detail:

Historically, the Highlands bighorn sheep range has overlapped with two small bands of domestic sheep located on private land near Maiden Rock in the East Pioneer Mountains. Semmens (1996) observed bighorn sheep using agricultural areas that supported these domestic sheep bands throughout the year, with the majority of use occurring in the fall. Bighorn sheep have used this overlapping area with domestic sheep for more than 20 years prior to the die-off in the mid-1990s and no problems with diseases had arisen in the past, although die-offs of wild sheep have been linked to domestic sheep and goat interactions in other areas. Presently, several domestic sheep hobby farms operate within proximity of the Highlands wild sheep range. There are no BLM or Forest Service sheep allotments, active or retired, in the Highlands or East Pioneer Mountains. The

need to monitor the Highlands herd on a regular basis for domestic sheep interactions and herd health continues to be a management concern. (2010a, 206)

If wild-domestic sheep interaction in the Highland and Pioneer Mountains was more of a concern in the early 1990s, it may have prevented or at least delayed a devastating pneumonia outbreak.

### Outbreak Summary

From 1994-1995, bighorns in the Highland/Pioneer Mountains experienced a pneumonia outbreak (Arthur et al. 1999; Aune et al. 1998). The MFWP said “the die-off was attributed to a pneumonia-lungworm complex” (2010a, 203). A 1992-1993 study “indicated an increased lungworm load and some significant gastrointestinal parasites within the population” (Aune et al. 1998, 50). Aune et al. went on to summarize the subsequent disease outbreak, which started in October 1994 (Aune et al. 1998):

By late November 1994, sheep hunters in the area reported observing clinical signs of pneumonia. Diagnostic work from two sheep mortalities confirmed pneumonia complex with strong evidence of chronic lungworm infection. Sheep mortalities continued to be recorded from December 1994 through March 1995. The population declined 87 percent and the current population contains less than 50 individuals. (1998, 50)

Researchers carried out carcass searches during the outbreak (Aune et al. 1998). A variety of pneumonia bacteria were found to have infected dead bighorns. Researchers also discovered seroprevalence for antibodies for P13 (a type of respiratory virus) among bighorns tested and stated that it “indicated significant challenge for bighorns in the Highlands-Pioneer herd unit prior to an epizootic” (Aune et al. 1998, 59). However, biologists did not discover the P13 virus itself in bighorn lung tissue. Researchers also hypothesized that high parasite loads may have predisposed the Highland/Pioneer bighorns to bacterial infection (Aune et al. 1998). Additionally, Aune et al. mention that:

The Highlands-Pioneer pneumonia epizootic was also characterized by a unique infection with the highly pathogenic *Pasteurella haemolytica* [now classified as *M. haemolytica*] type A2 as well as the more common type, T-3,4. It is likely that the cytotoxic A2 isolate originated from domestic sheep that share habitat with these bighorn sheep yearlong. Several reports of bighorn rams breeding with and mingling with domestic sheep ewes were recorded prior to the pneumonia outbreak. (1998, 64)

Aune et al. go on to speculate that the significant increase in the Highland/Pioneer bighorn population in the early 1990s increased the risk of wild-domestic sheep disease transmission (1998). Despite subsequent augmentation transplants, Highland/Pioneer bighorn counts performed after the 1990s disease outbreak have regularly shown fewer than 50 animals. Lamb recruitment has also remained suppressed. For example, in 2008, over 90 percent of new lambs died from pneumonia (MFWP 2010a). In early 2013, an estimated 50-75 bighorns inhabited the Highland and Pioneer Mountains (Boccardori 2013).

#### Policy Documents

The policies of Montana's 2010 bighorn plan are too recent to apply to this disease outbreak (MFWP 2010a). Much of the Highland/Pioneer bighorn range was/is on BLM land, so the BLM's 1992 *Guidelines for Domestic Sheep Grazing in Bighorn Sheep Habitats* would have applied to sheep grazing on BLM land in the area (BLM 1995a). However, there were no public domestic sheep grazing allotments in Highland/Pioneer bighorn range. Known domestic sheep occurred on private land, so the 1992 guidelines were not necessarily applicable or enforceable (MFWP 2010a). Additionally, an inquiry to the BLM's Butte Field Office did not reveal any site-specific BLM bighorn-domestic sheep interaction guidelines in the Highland or Pioneer Mountains (LaMarr 2012). An examination of the BLM's 1979 *Management Framework Plan: Dillon Summary*,

*Montana* (covered the Highland/Pioneer Mountains at the time of the outbreak) also revealed no BLM bighorn-domestic sheep interaction policies (BLM 1979).

Highland/Pioneer bighorn habitat includes portions of the Beaverhead-Deerlodge National Forest, which was created from the melding of two national forests into one administrative unit in 1996 (USFS 2012a). Thus, a look at the management plans in place for both the Beaverhead and Deerlodge National Forests in 1994 is relevant to this analysis. An examination of the 1986 plan for the Beaverhead National Forest revealed no wild-domestic sheep interaction policies (USFS 1986a).

Though not directly addressing bighorn-domestic sheep interactions, the 1987 plan for the Deerlodge National Forest refers to policy regarding bighorn conflicts with livestock (USFS 1987). A standard of the plan is to: “Protect occupied bighorn sheep and mountain goat range during resource activities. Include requirements in project plans for livestock, timber, or other resource development to avoid or mitigate impacts on the range. Resolve conflicts in favor of these species” (USFS 1987, II-18). An inquiry to the Beaverhead-Deerlodge National Forest reveals that no USFS bighorn-domestic sheep interaction policies were in place in the Highland or Pioneer Mountains in 1994-1995 because there were no domestic sheep grazing allotments in the Forest (Rohrbacher 2012).

Now that a summary has been offered on the 1994-1995 Highland/Pioneer Mountains bighorn die-off and its related factors, important background information is in place to provide a better understanding of particular policies relevant to that outbreak. Policies are analyzed through questions that form the nine policy analysis criteria.

## POLICY ANALYSIS CRITERIA

### ***1.) Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?***

#### *Answer and Explanation*

Buffer zones were not in place (Frisina 2012). Michael R. Frisina was the MFWP biologist in Butte at the time of the outbreak. He emphasizes that the separation issue was not a consideration when the Highland/Pioneer population was established in 1967 (2012).

### ***2.) Were special supervision rules in place for sheepherders?***

#### *Answer and Explanation*

This policy analysis criterion is not applicable because, according to MFWP: “There are no BLM or Forest Service sheep allotments, active or retired, in the Highlands or East Pioneer Mountains” (2010a, 206). Small bands of domestic sheep on private land were likely the only sheep in the area (MFWP 2010a).

### ***3.) Were domestic sheep trailing restrictions in place to ensure separation?***

#### *Answer and Explanation*

This criterion is not applicable because of the lack of domestic sheep allotments in Highland/Pioneer bighorn range (MFWP 2010a).

### ***4.) Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?***

#### *Answer and Explanation*

Domestic sheep presence in the Highland and Pioneer Mountains was not considered prior to reintroducing bighorns because, back in 1967, the bighorn-domestic sheep disease issue was not a prominent concern for Montana biologists (Frisina 2012).

**5.) Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?**

Answer and Explanation

This criterion is not applicable because of the absence of public land domestic sheep grazing allotments in Highland/Pioneer bighorn habitat (MFWP 2010a).

**6.) Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?**

Answer and Implementation

Efforts to negotiate with domestic sheep owners were attempted in the range of Highland/Pioneer bighorns. According to Frisina: “Efforts were made to discuss concerns with private land owners, but the primary landowner was not cooperative and refused to take the issue seriously. The other landowner made a concerted effort to keep his domestic sheep away from wild sheep” (2012).

**7.) If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?**

Answer and Explanation

While this question was written with wild sheep in mind, it could be read either way. Regarding MFWP policy, Frisina remarked: “There is no authority to remove domestic sheep from private lands” (2012). The fact that MFWP allowed bighorns to mingle with domestic sheep for over 20 years before the outbreak (Aune et al. 1998) indicates that it is highly unlikely any efforts were made to fatally remove bighorns to prevent disease spread.

***8.) Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?***

***Answer and Nature***

Coordination existed (Frisina 2012), and tension seems likely. According to Frisina: “MFWP cooperated with the BLM in developing guidelines regarding bighorn sheep/wildlife sheep interactions. This was a long slow bureaucratic process that never got very far at the local level” (2012).

***9.) Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?***

***Answer and Explanation***

For wild-domestic sheep interaction management in the Highland and Pioneer Mountains, funding difficulties were not a concern (Frisina 2012). Frisina remarked that “there was nothing FWP could do about the existence of domestic sheep on private lands. The landowners did not want to have anything to do with government funding to eliminate domestic sheep from the area” (2012).

***Policy Efficacy Summary***

Regarding management of wild and domestic sheep in the Highland/Pioneer Mountains before that area’s die-off, no especially effective policies stand out, partly because many policies were not applicable due to that region not hosting domestic sheep grazing allotments (MFWP 2010a). The Highland/Pioneer Mountains lacked buffers between wild and domestic sheep (Frisina 2012), but with no public sheep allotments, buffer policies could not be feasibly enforced. Not considering the presence and threat of domestic sheep before reintroducing bighorns to the Highland/Pioneer Mountains (Frisina 2012) represents a significant policy gap that may have contributed to the area’s



1994-1995 disease outbreak. Negotiation/education concerning local sheep producers may have had some successes that delayed disease (i.e. according to Frisina, one producer cooperated with MFWP), but it was ineffective, considering a primary domestic sheep producer did not take the disease issue seriously. Agency coordination concerning the Highland/Pioneer wild-domestic sheep situation was also slow and did not get far (Frisina 202), which indicates that it was ineffective.

## SECTION 4 – TARRYALL/KENOSHA MOUNTAINS, COLORADO: 1997-2000

### Introduction

The Tarryall Mountains (39° 13' 54.41"N, 105° 31' 43.15"W) and Kenosha Mountains (39° 21' 55.06"N, 105° 36' 21.32"W) are connected mountain ranges in central Colorado's Park County. They are located about 64 km (40 mi) southwest of Denver (George et al. 2008; Google Earth 2012). These mountains primarily lie in the Pike National Forest (Google Earth 2012).

According to the Colorado Division of Wildlife (CDOW), the Tarryall/Kenosha "bighorn population is composed of three relatively discrete herds with separate winter ranges (Kenosha Mountains, Sugarloaf Mountain, and Twin Eagles). Within this population, there is little interchange of ewes among herds but considerable commingling and exchange of rams" (2009, 12). Because of the interchange, the Tarryall and Kenosha bighorns are managed as a single population (USFS 2007).

In a pre-outbreak 1990s study, George et al. described the range of Tarryall/Kenosha bighorns by dividing their habitat into two main subunits:

The Kenosha Mountains . . . subunit was approximately 65 km<sup>2</sup> and contained 1 subpopulation that ranged in the Kenosha and Platte River Mountains, and N. Tarryall Peak area. Elevation ranged from 2,800-3,800 m [9,186-12,467 ft]. Bighorns were primarily found on alpine tundra and on mixed grass slopes interspersed with bristlecone pine (*Pinus aristata*), Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), Englemann spruce (*Picea englemannii*), aspen (*Populus tremuloides*) and rock outcrops. Willows (*Salix* spp.) and large stands of conifers were used occasionally. Escape cover consisted of rock outcrops that seldom exceeded 100 m [328 ft] in vertical relief.

The Tarryall Mountains . . . subunit, was approximately 130 km<sup>2</sup>, abutted the southeastern boundary of the [Kenosha Mountains subunit], and contained 2 bighorn subpopulations [Sugarloaf Mountain and Twin Eagles]. Topographic relief was greater than in the [Kenosha Mountains subunit], with cliffs and rock outcrops often exceeding 200 m [656 ft] in vertical relief. Elevation ranged from

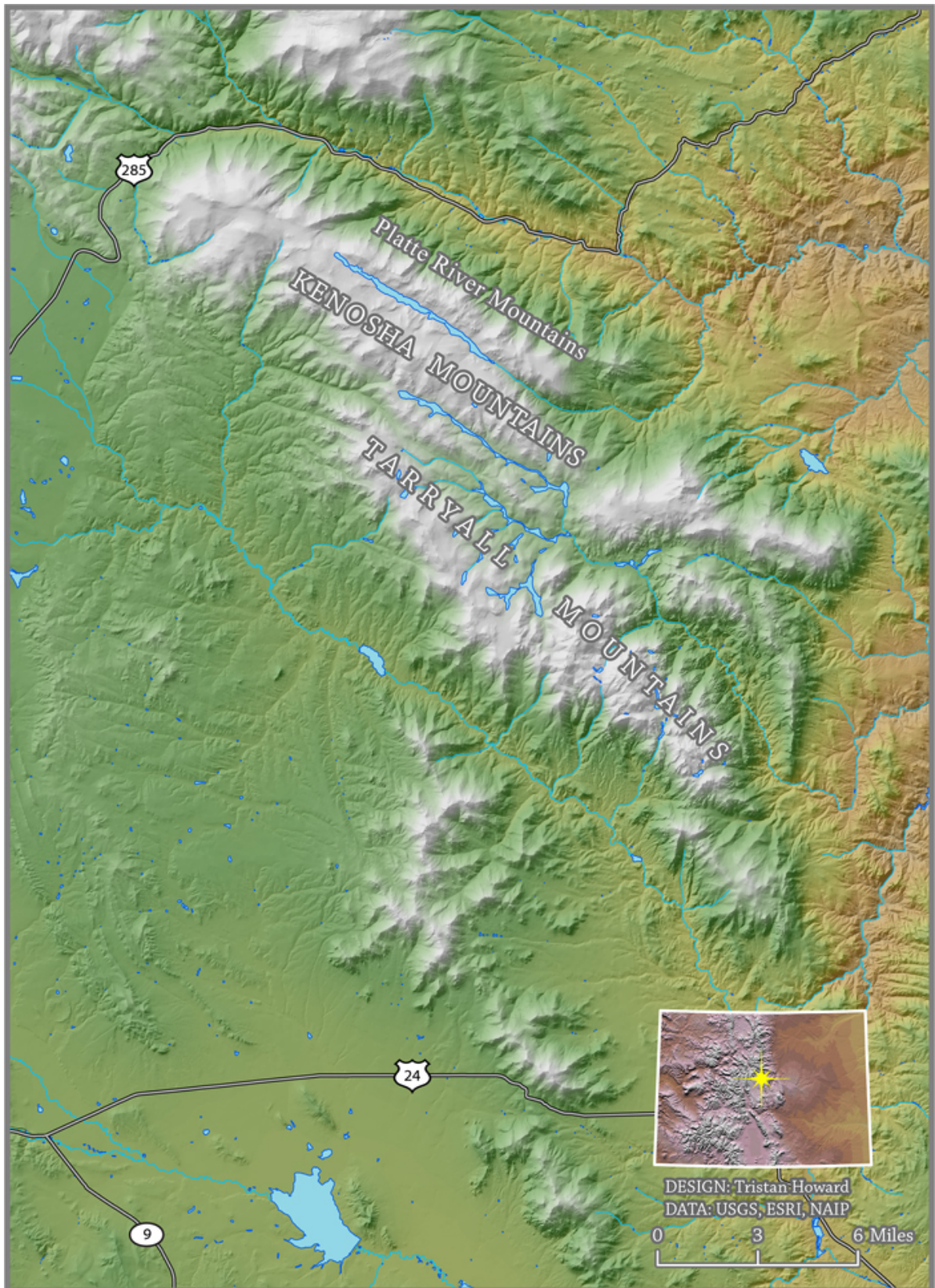


Figure 4.7. Tarryall/Kenosha Mountains terrain.



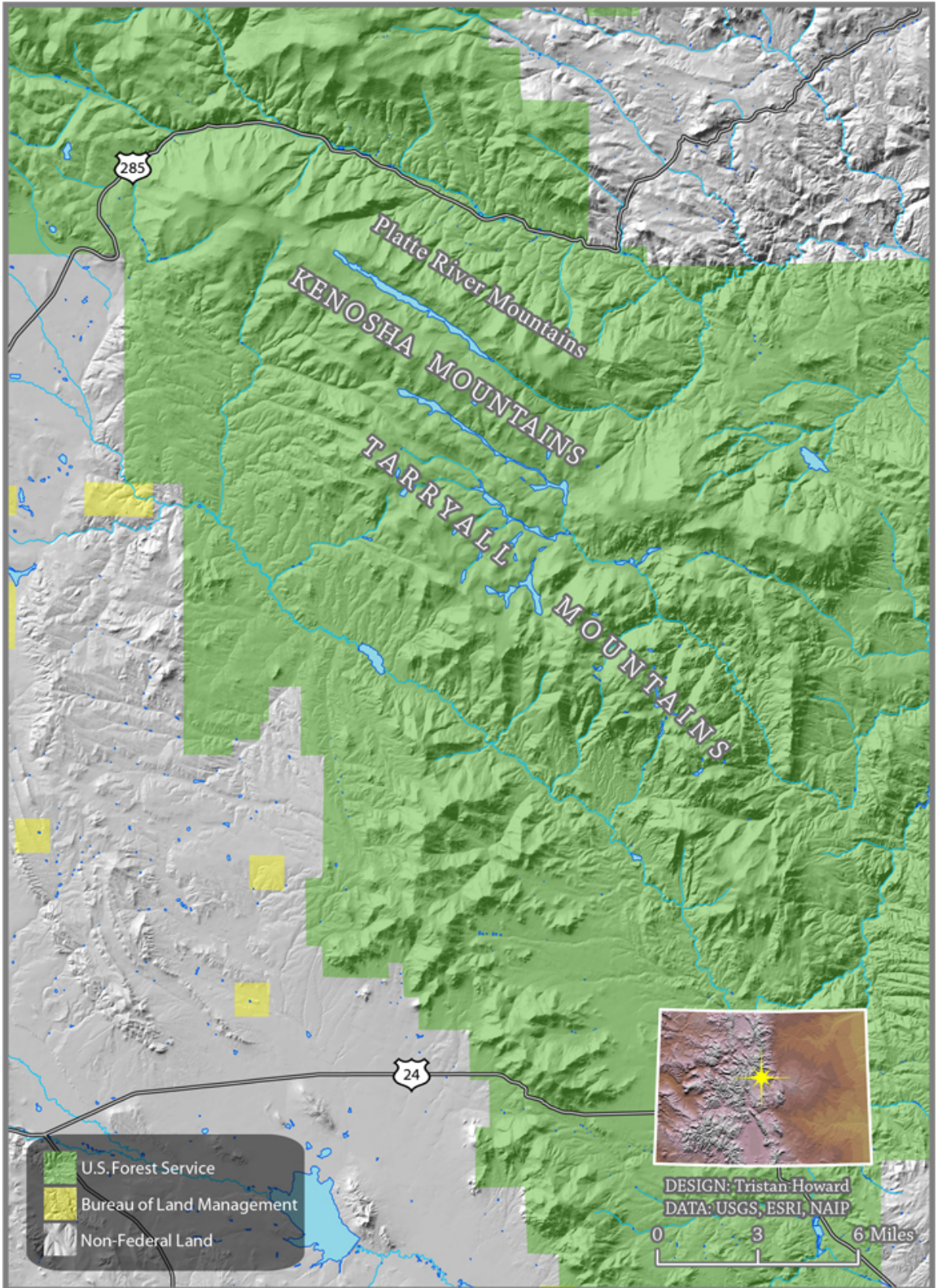


Figure 4.8. Tarryall/Kenosha Mountains federal land ownership.

2,400-3,800 m [7,874-12,467 ft]. During March and April most bighorn used mixed grass slopes interspersed with Ponderosa pine and aspen, and riparian meadows along Tarryall Creek. Bighorn also used steep, broken slopes with conifer cover approaching 50%. Alpine tundra and dense stands of Douglas fir and Englemann spruce received little use in winter and spring. (1996, 21)

Bighorns in the Tarryall Mountains congregated at lower elevations along Tarryall Creek in winter with the Twin Eagles herd wintering about 15 km (9 mi) downstream of the Sugarloaf herd (George et al. 2008). George et al. add that Kenosha bighorns “occasionally congregated in subalpine habitats in late winter or spring in Black Canyon and Long Gulch. [Their] range was separated from the other two herds by at least 10 km (6 mi) during all seasons” (2008, 390-391).

The Rocky Mountain bighorn population in the Tarryall/Kenosha Mountains is native, so no reintroduction was necessary to establish wild sheep there (Toweill and Geist 1999). A domestic sheep (that likely originated from private lands) was observed with Tarryall/Kenosha bighorns during their 1997-2000 pneumonia outbreak (George et al. 2008; USFS 2007). That outbreak reduced both overall bighorn numbers and subsequent lamb recruitment rates (George et al. 2008; USFS 2007). No policy documents were discovered that both covered wild-domestic sheep interaction in the Tarryall/Kenosha Mountains *and* would have been applicable at the time of the area’s outbreak.

The policy analysis criteria addressing buffers, sheepherder supervision rules, trailing restrictions, consideration of domestic presence before reintroduction, and grazing alteration efforts are not applicable to the Tarryall and Kenosha Mountains because no public land domestic sheep allotments existed in the area, and the ranges’ bighorns were native (George 2012; USFS 2007; Toweill and Geist 1999). Some

education of local domestic sheep owners occurred because of the Tarryall/Kenosha outbreak. Bighorns near domestic sheep in the area were not removed from the wild. Regarding management of the Tarryall/Kenosha wild-domestic sheep issue, coordination existed, tension was unlikely, and there were no funding difficulties (George 2012). Before analyzing specific interaction policies, it helps to first have background information on the history of bighorns in the Tarryall and Kenosha Mountains.

#### *Bighorn Population History Prior to Outbreak*

Unlike the other bighorn populations profiled in this study, wild sheep composing the Tarryall/Kenosha population were not reintroduced. They were native to their range before, during, and after Euro-American settlement (Toweill and Geist 1999). The CDOW provides a summary of this population's earlier struggles with disease:

In the late 1800s, die-offs were reported in bighorn sheep in the Tarryall Mountains . . . . In 1953, the state's largest bighorn population residing in the Tarryall and Kenosha Mountains experienced a die-off caused by pneumonia that reduced the population from an estimated 1,000 animals (some observers have said 2,000) to 30 within two years; the Tarryall-Kenosha epidemic likely extended from a 1952 outbreak on Pikes Peak. The causes of these early die-offs are hard to verify retrospectively, but contact with domestic livestock that led to the introduction of exotic diseases and parasites seems the most logical explanation. (CDOW 2009, 1)

This die-off was among Colorado's first well-documented wild sheep epizootics that affected all ages of bighorns. In 1996, about 375 bighorns lived in the Tarryall/Kenosha population (CDOW 2009). A portion of this bighorn population's habitat was only about 14 km (8.7 mi) from fenced domestic sheep (George 2012).

#### *Nearby Domestic Sheep*

On December 18, 1997 (after the beginning of the Tarryall/Kenosha outbreak and the discovery of nine wild sheep carcasses), a field technician was tracking bighorns on

Sugarloaf Mountain when he saw a domestic sheep ram. George et al. describe what happened next:

When first observed, the domestic sheep appeared to be following the technician. However, when the technician tried to approach the domestic sheep it fled and joined a nearby group of bighorn sheep. According to his notes, “Several attempts were made by the bighorns to keep the domestic male away but it was persistent and eventually allowed to graze with them.” (T. Verry, unpubl. field notes, CDOW and United States Forest Service). We made unsuccessful attempts to capture the domestic sheep and to locate its owner later that day and again on the morning of 19 December. We subsequently shot the domestic sheep on 19 December while it was still associated with a group of bighorn sheep . . . . The carcass of the domestic sheep was transported to CSUDL for necropsy. This was the first (and only) time during our 10-yr study that a domestic sheep was found with bighorn sheep on range in the study area. (2008, 393)

George et al. add that “given the domestic sheep’s recalcitrance and the difficulty of observing it against the snow pack, we believe this animal may have been present somewhere on the Sugarloaf Mountain winter range for several weeks prior to being detected” (2008, 398). According to the USFS, regarding the Tarryall/Kenosha bighorn population: “There is no history of domestic sheep and goat allotments on public lands within the herd units, pointing to hobby flocks on private land as the probable source of exposure to pneumonia. Disease is likely to be a significant, chronic threat to this herd” (USFS 2007, 43).

Colorado Parks and Wildlife (new name for CDOW) biologist Janet George notes that “the domestic sheep appeared from an unknown source and no owner was ever identified” (2012). George adds that:

. . . a small, fenced private collection of domestic sheep/goats was identified about 14 km [8.7 mi] from where the outbreak started . . . . The origin of the stray domestic ram associated with the disease outbreak remains unknown and there is no evidence it came from the small private collection. (2012)

While its origins may be uncertain, a domestic sheep was the likely source of a major bighorn pneumonia outbreak in the Tarryall and Kenosha Mountains.

### Outbreak Summary

From 1997-2000, bighorns inhabiting the Tarryall and Kenosha Mountains experienced a pneumonia outbreak that reduced bighorn numbers and subsequent lamb recruitment (George et al. 2008). According to George et al.: “The onset of this epidemic coincided temporally and spatially with the appearance of a single domestic sheep . . . on the Sugarloaf Mountain herd’s winter range in December 1997” (2008, 388).

On December 2, a dead radiocollared bighorn ewe was discovered on Sugarloaf Mountain. A necropsy performed the next day diagnosed the ewe with pneumonia. From December 8-19, eight more bighorn carcasses were found—all within about one km (0.6 mi) of the discovery location of the original dead ewe. Two of these carcasses were found to be infected with pneumonia (George et al. 2008).

Soon after the outbreak started, CDOW took action. Agency staff knew local bighorn movement patterns and predicted that bighorn rams from the Sugarloaf Mountain herd would spread the disease when they dispersed in late winter and summer. So, wildlife managers vaccinated seven bighorns in the Sugarloaf Mountain herd and a combined total of 39 bighorns in the nearby Twin Eagles and Kenosha Mountains subpopulations. Managers administered vaccinations via hand injections, projectile syringes, and biobullets (George et al. 2008). The summary of George et al. adds:

Although only bighorns in the Sugarloaf Mountain herd were affected in 1997–98, cases also occurred during 1998–99 in the other two wintering herds, likely after the epidemic spread via established seasonal movements of male bighorns. In all, we located 86 bighorn carcasses during 1997–2000. Three species of *Pasteurella* were isolated in various combinations from affected lung tissues from 20 bighorn carcasses where tissues were available and suitable for diagnostic



evaluation; with one exception, b-hemolytic *Mannheimia (Pasteurella) haemolytica* . . . was isolated from lung tissues of cases evaluated during winter 1997–98. (2008, 388)

The 1997-2000 Tarryall/Kenosha disease outbreak directly killed at least 72 bighorns—approximately 28 percent of the estimated population. Vaccination of bighorns and removal of the nearby domestic sheep did not prevent substantial mortality or improve later lamb recruitment (George et al. 2008). George et al. remark that “the resulting depression in the . . . bighorn population’s survival, recruitment, and size followed the appearance of a single domestic sheep on native bighorn winter range and occurred in the absence of other known or suspected inciting factors, illustrating the potential consequences of contact between these species under natural conditions” (2008, 395-396).

According to the USFS, “lamb:ewe ratios fell from pre-epizootic levels of 40 to 50:100 to a post-epizootic level of 0:100, and they have only increased to about 25:100 since 2002” (2007, 43). Post-hunt estimates indicate about 110 bighorns lived in the Tarryall/Kenosha population in 2012 (CDOW 2012). These bighorns are a long way from recovering to their 1996 pre-outbreak population level of about 375 animals (CDOW 2009). An analysis of policy documents was undertaken in an effort to gain insights on why wildlife managers failed to prevent the Tarryall/Kenosha bighorn population from reaching such a precarious, suppressed position.

### Policy Documents

Colorado’s 2009 bighorn management plan devotes much attention to the wild-domestic sheep disease problem. It even has a section dedicated to “Bighorn Sheep-Domestic Livestock Disease Interactions.” However, the plan lists current and

aspirational strategies and goals without specifically referencing older interaction policies that were in place from 1997-2000 (CDOW 2009).

The 1984 land and resource management plan for the Pike and San Isabel National Forests covers the range of the Tarryall/Kenosha bighorns and was in place at the time of the outbreak (USFS 1984). The plan mentions domestic sheep grazing allotments, but according to the USFS, there were no sheep allotments within Tarryall/Kenosha bighorn range (USFS 1984, 2007). The Pike and San Isabel National Forests only had four permitted domestic sheep bands in 1984. The Pike/San Isabel plan lists bighorns as a management indicator species, but it does not address any specific policies regarding wild-domestic sheep separation (USFS 1984). An inquiry to the Pike National Forest revealed that no USFS bighorn-domestic sheep interaction policies were in place in the Tarryall/Kenosha region from 1997-2000 (Meyer 2012).

Now that exposition has been offered on the Tarryall/Kenosha Mountains bighorn die-off and elements related to it, one is better equipped to analyze specific wild-domestic sheep interaction policies.

#### POLICY ANALYSIS CRITERIA

##### ***1.) Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?***

##### ***Answer and Explanation***

Wild-domestic sheep separation buffer zones were not in place on Tarryall/Kenosha bighorn range (George 2012). According to George: “There were no known domestic sheep within or nearby the range of the Tarryall-Kenosha Mountains bighorn range so no need for a buffer” (2012).

**2.) *Were special supervision rules in place for sheepherders?***

*Answer and Explanation*

This criterion is not applicable because no public land domestic sheep or goat grazing allotments existed in the Tarryall or Kenosha Mountains during the disease outbreak (USFS 2007).

**3.) *Were domestic sheep trailing restrictions in place to ensure separation?***

This criterion is not applicable because of the absence of domestic sheep grazing allotments in the Tarryall and Kenosha Mountains (USFS 2007).

**4.) *Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?***

*Answer and Explanation*

This criterion is not applicable because bighorns in the Tarryall/Kenosha Mountains were native and not reintroduced (Toweill and Geist 1999).

**5.) *Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?***

*Answer and Explanation*

This criterion is not applicable because there were no local domestic sheep allotments to buy out (USFS 2007).

**6.) *Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?***

*Answer and Implementation*

Though it did not happen before the outbreak, agency-initiated education of at least one private landowner took place because of the Tarryall/Kenosha die-off. A small group of fenced domestic sheep and goats existed on private land about 14 km (8.7 mi) from the epizootic's starting location (George 2012). According to George, after the

outbreak: “Local field staff contacted the owner and explained the risk to bighorns” (2012).

***7.) If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?***

*Answer and Explanation*

No bighorns in the Tarryall or Kenosha Mountains were ever removed from the wild because of proximity to domestic sheep. George remarked: “No wandering bighorns associated with the Tarryall herd have been identified approaching domestic sheep” (2012).

***8.) Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?***

*Answer and Nature*

Coordination existed at the state level. In the answers to a questionnaire presented to biologists at the 2nd North American Wild Sheep Conference in 1999 (Table 2.1 on page 52), John Ellenberger states: “In general, conflicts between state and federal agencies have been minimal. Preserving and maintaining sheep populations and their habitats is a high priority for all agencies in the state” (Arthur et al. 1999, 397). Ellenberger adds: “We are beginning cooperative management of domestic sheep allotments in proximity to bighorn herds. This project is in the early stages and will probably face some opposition from land management agencies as well as livestock operators” (Arthur et al. 1999, 397).

***9.) Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?***

**Answer and Explanation**

This criterion is not applicable because of the lack of knowledge of domestic sheep in Tarryall/Kenosaha bighorn range in the 1990s (George 2012). Regarding management before the die-off, George notes that there were no known “domestic sheep within the Tarryall bighorn range so no need for funding” (2012).

**Policy Efficacy Summary**

The main policy trend that stands out for the Tarryall/Kenosha Mountains was that various wild-domestic sheep interaction policies were not applicable there. This is because of a lack of domestic sheep allotments in the area and the native status of the Tarryall/Kenosha bighorns (USFS 2007; Toweill and Geist 1999). The area lacked clear wild-domestic separation buffers, education occurred, and bighorns near domestic sheep were not removed from the wild (George 2012). These missing but applicable policies may have contributed to disease. Considering the fact that hobby animals were the main domestic sheep nearby (USFS 2007) and the mystery surrounding the lone domestic sheep that may have initiated the bighorn die-off (George et al. 2008), domestic sheep presence was probably not prominent enough for agencies to consider implementing the above policies. Education of a local sheep owner occurred, but it happened after the die-off (George 2012), which was too late for it to be effective.

## **SECTION 5 – HAYS CANYON RANGE, NEVADA: 2007**

### **Introduction**

The Hays Canyon Range (41° 20' 31.65"N, 119° 57' 23.73"W) lies very near the California border in northwest Nevada's Washoe County. It is located about 48 km (30 mi) east of Alturas, California (Google Earth 2012). According to the BLM's 1995 mountain sheep ecosystem management strategy, the Hays Canyon Range bighorn habitat bioregion is 85 percent BLM land and 15 percent private land (BLM 1995).

Regarding the Hays Canyon Range, NDOW states: "The western front of the range rises dramatically from the high altitude alkali flats near Eagleville, CA, to its rugged peak at 7900 feet" (2008a, 1). Heavy tree cover exists in some northern portions of the range (NDOW 2008a). However, much of the mountains are sparsely vegetated (Google Earth 2012). The Hays Canyon Range is within the Surprise District of the BLM's management scheme. According to the BLM, in this district, "dominant vegetation types include grasslands, Great Basin shrubs, sagebrush, mixed sage-western juniper, western juniper, conifer, and riparian formations" (BLM 2007a, 3-1). The Hays Canyon Range is near the Great Basin's extreme western edge, which terminates at the Warner Mountains (BLM 2007a).

Surprise Valley in California separates (sometimes with as little as 11 km [7 mi] in some areas) the Hays Canyon Range from the adjacent Warner Mountains to the west (Google Earth 2012). The Warner Mountains hosted bighorns before Euro-American settlement and in the 1980s after reintroduction (Meintzer 2009). However, in 1988, a pneumonia-caused die-off (attributed to domestic sheep pathogens) completely wiped out the population (Bleich et al. 1990). The BLM notes that "in recent years, the lack of

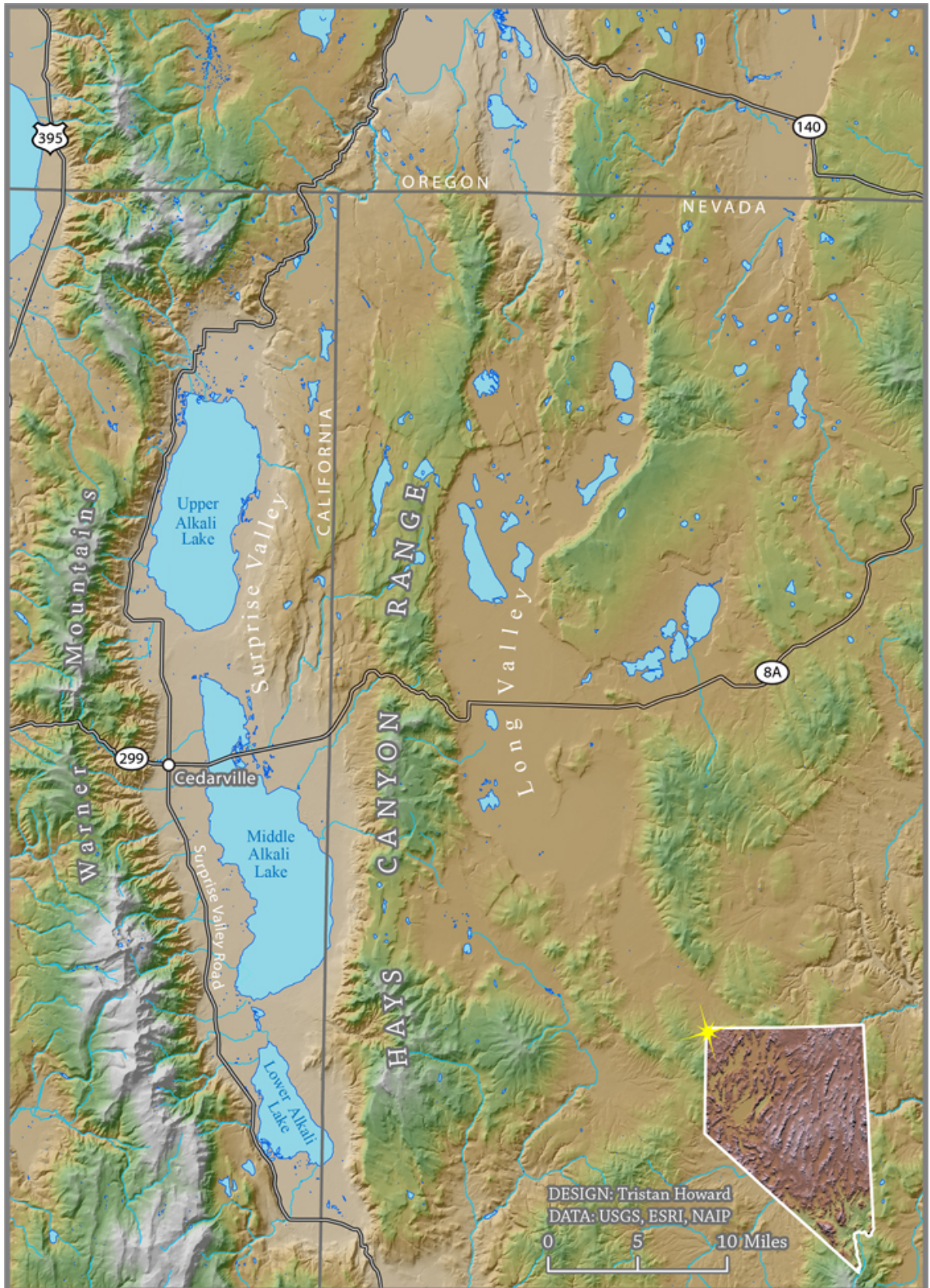


Figure 4.9. Hays Canyon Range terrain.



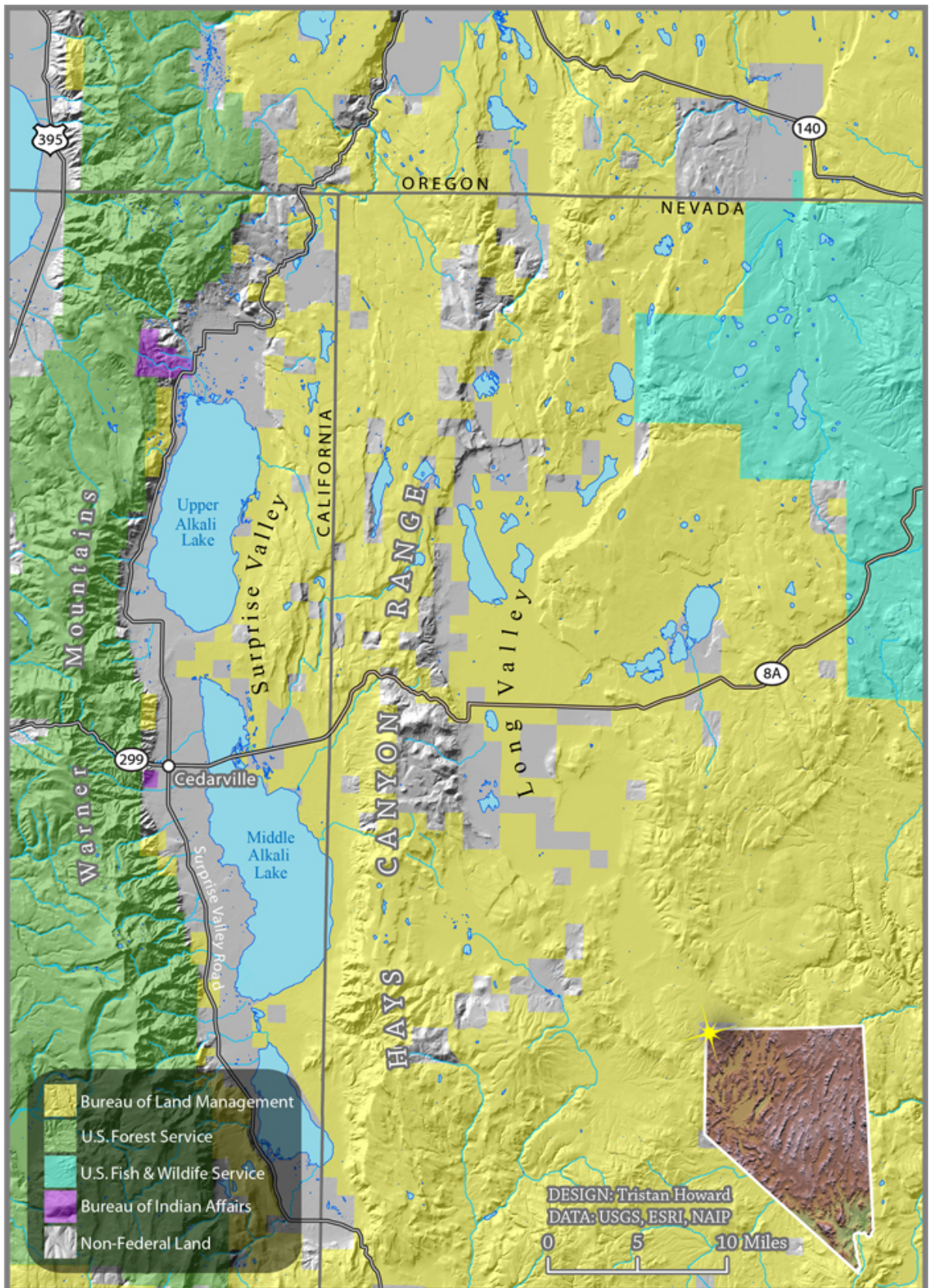


Figure 4.10. Hays Canyon Range federal land ownership.



water in bighorn ranges has forced a few bighorn sheep [from the Hays Canyon Range] to cross over to the Warner Mountains” (BLM 2007a, 3-117).

A population of California bighorns was reestablished in the Hays Canyon Range in 1989 (NDOW 2008a). The new population expanded in size and distribution, which brought them closer to domestic sheep (NDOW 2006). In 2007, thousands of domestic sheep were authorized to graze on a BLM allotment located along the southern part of the Hays Canyon Range (BLM 2007a, b). Nearby domestic sheep also existed on private lands (Surian 2012). In 2007, a pneumonia outbreak terminated the existence of bighorns in the Hays Canyon Range (NDOW 2008a; Dobel 2012a). Important policy documents applied to the Hays Canyon Range in 2007 and directly addressed the wild-domestic sheep disease problem. These documents include a 2007 BLM proposed resource management plan, the BLM’s 1998 guidelines for managing domestic sheep and goats in wild sheep habitat, and NDOW’s 2001 bighorn management plan (BLM 2007a, 1999; NDOW 2001).

Concerning particular bighorn-domestic sheep interaction policies, just prior to its wild sheep die-off, the Hays Canyon Range lacked buffers, shepherd supervision rules, and trailing restrictions (Flores, Jr. 2012). Nonetheless, domestic sheep presence was considered before bighorn reintroduction, grazing allotment alteration was implemented, negotiation and education occurred, and at least one bighorn near domestic sheep was removed from the wild (Flores, Jr. 2012; Epps et al. 2003). Additionally, both coordination and tension existed between agencies, and funding difficulties were not an issue (BLM 2007a; NDOW 2001; Soletti 2012; Flores, Jr. 2012; Dobel 2012a). Before specifically analyzing policies that influenced bighorn-domestic sheep interaction in the

Hays Canyon Range, it helps to have some history on the area's bighorns before pneumonia extirpated them.

#### *Bighorn Population History Prior to Outbreak*

In December 1989, wildlife managers transplanted 15 California bighorns to the Hays Canyon Range from Williams Lake, British Columbia. In 1995, the population was augmented with an additional 15 animals from northwest Nevada's Jackson and Santa Rosa Mountains (NDOW 2008a). The NDOW provides a Hays Canyon Range bighorn population history prior to the outbreak:

Production and recruitment levels for the . . . bighorn herd have been very good since they were first released . . . . The herd has averaged 56 lambs per 100 ewes since that time. In recent years the observed lamb ratio has been even higher. This has allowed the population to continue to expand in both number and distribution. Recent observations of bighorn in the southern portion of the Hays Canyon Range are further proof that this herd continues to do well and that the herd is expanding into other good quality sheep habitats that are available. However, there is increasing concern with escalating domestic goat and sheep operations . . . and the potential for interaction with our wild sheep population. (2006, 69-70)

The NDOW remarks that "at one point, [the Hays Canyon Range population] was considered to have among the highest ewe to lamb ratios in Washoe County" (2008a, 1). An estimated 110 bighorns inhabited the Hays Canyon Range in 2006-2007 (NDOW 2008a). Although the Hays Canyon Range hosted many bighorns by the early twenty-first century, they may have been greatly out-numbered by nearby domestic sheep.

#### *Nearby Domestic Sheep*

According to the BLM's May 2007 *Proposed Resource Management Plan and Final Environmental Impact Statement* for the Surprise District (Surprise PRMP): "Grazing of domestic sheep would continue on the Tuledad, Selic-Alaska, and Red Rock Lake allotments" (BLM 2007a, 2-37). In 2007, these were the only allotments near the

Hays Canyon Range containing domestic sheep (BLM 2007a). According to BLM biologist Scott Soletti: “The allotments that contained bighorn sheep were cattle grazing only allotments” (2012).

In 2007, the Selic-Alaska and Red Rock Lake allotments were located west of the Warner Mountains in California, so their domestic sheep may not have posed a significant threat to bighorns because of topography. However, the Tuledad Allotment was located along the southern portion of the Hays Canyon Range, so domestic sheep may well have been near bighorns at the time of the outbreak (BLM 2007a). In 2007, the Tuledad Allotment hosted five cattle operators and one operator who ran both cattle and sheep. For sheep, the BLM permitted 2,352 AUMs on the allotment in 2007 (BLM 2007b).

According to the BLM, “an AUM is the amount of forage needed to feed a cow, one horse or five sheep for one month” (2011a). Pratt and Rasmussen provide a more complete definition:

The animal unit month (AUM) concept is the most widely used way to determine the carrying capacity of grazing animals on rangelands. The AUM provides us with the approximate amount of forage a 1000 lb cow with calf will eat in one month. It was standardized to the 1000 lb cow with calf when they were the most prevalent on rangeland. This AUM was established to be 800 lbs of forage on a dry weight basis (not green weight). All other animals were then converted to an “Animal Unit Equivalent” of this cow. For example, a mature sheep has an Animal Unit Equivalent of 0.20. This means a sheep eats about 20% of the forage a cow will eat in one month. (2001)

This definition indicates the BLM allowed 11,760 ( $5 \times 2,352$ ) domestic sheep to graze on the Tuledad Allotment in 2007.

The NDOW confirmed the nearby presence of domestic sheep in its 2005-2006 state big game status report where it stated: “Domestic sheep trailing routes and grazing

areas are . . . located in the valley bottoms surrounding the southern portions of the Hays Canyon Range. As this bighorn population expands, the likelihood for a disease related die-off due to interactions with domestic sheep or goats increases” (2006, 70). The NDOW repeated such concerns in its 2006-2007 status report in which it stated: “The movement of bighorn to the south-end of the range puts the bighorn closer to domestic sheep grazing and trailing routes and increases the likelihood of nose to nose contact” (2007, 72).

Regarding the Hays Canyon Range disease outbreak, in June 2012, Steve Surian (the BLM’s Supervisory Rangeland Management Specialist for the Surprise District) stated that “there [have] been discussions (rumors) [that] the source of the epizootic may have been from goats and/or domestic sheep located on private lands near Farmers springs, which is located between 49 Mountain and Bull Creek, east of Cedarville” (2012).

The history of domestic sheep in the Hays Canyon Range area is dynamic. The NDOW’s Western Region Supervising Biologist Mike Dobel provides the important insights that follow. According to Dobel, the Tuledad Allotment was active in 1989 at the time of the original transplant. However, in 1989, domestic sheep used a different part of the allotment than they used in 2007 when the outbreak happened. There were also a number of years when nobody used the Tuledad Allotment to graze domestic sheep. For some time, the Tuledad Allotment was also used mainly for trailing sheep, and they were trailed pretty far south of bighorn range. Nonetheless, there were sightings of bighorn rams entering the Tuledad Allotment (Dobel 2012a).

At least two different livestock operators used the Tuleadad Allotment after bighorns were reintroduced to the area in 1989. At one point, one sheep operator bought out another. The new operator grazed domestic sheep much closer to bighorns than they had ever been before. He began wintering his sheep at the south end of the Hays Canyon Range. He was also uncooperative, stubborn, and uncommunicative. He did not have a good relationship with NDOW or the BLM. Furthermore, he did not believe domestic sheep posed a disease risk to bighorns. This operator substantially increased the area's wild-domestic sheep disease transmission risk factor (Dobel 2012a).

Back when wild sheep roamed the Hays Canyon Range, Nevada had an estray livestock law which precluded NDOW from shooting stray domestic sheep to remove their threat to bighorns. To legally remove domestic sheep, NDOW had to seek permission from the State Department of Agriculture and the permittee responsible for the stray sheep. This led to live-capturing and net-gunning of domestic sheep. The NDOW put significant effort into capturing domestic sheep alive. This was partly to take samples from domestic sheep to test for disease and aid with research efforts. Live removals of domestic sheep were also part of an attempt to clear the range and reduce the domestic disease threat. Live-capture of domestic sheep occurred in the Hays Canyon Range area and many other areas across the state (Tanner 2012a, b). Despite the preventative efforts of Nevada's wildlife biologists, domestic sheep may well have caused a devastating bighorn pneumonia outbreak in 2007.

#### Outbreak Summary

The Hays Canyon Range bighorn pneumonia outbreak seems to have primarily struck in late summer, fall, and early winter of 2007 (NDOW 2008a). Nevada Bighorns

unlimited (NBU)—a bighorn advocacy group—cooperated with NDOW in investigating this die-off (NBU 2011; NDOW 2008a). The NDOW presents a summary of the Hays Canyon Range pneumonia epizootic:

The news of a possible disease event in this area came from a 2007 bighorn sheep tag-holder. While driving into Hay's Canyon [in early October] he observed what appeared to be a sick ewe bedded down under a tree close to the road; the same animal was found dead a few hours later. NDOW Law Enforcement followed up on his report and helped retrieve the carcass which was then transported to Reno for veterinary diagnostic work-up and a thorough necropsy examination. The results of the examination, backed up by various laboratory results, confirmed that the ewe died from severe bacterial pneumonia. Both *Biebersteinia* (formerly *Pasteurella*) *trehalosi* and a common pus-forming bacterium, *Arcanobacterium*, were cultured from the lesions in the lungs. The ewe also showed scarring in the lungs that suggested *Mycoplasma* infection (*Mycoplasma ovipneumoniae*). This particular species of *Mycoplasma* was implicated in the deaths of bighorn sheep in Idaho, Washington and Oregon in 2006, although in that instance, a host of other factors probably were involved.

NDOW performed an intensive follow-up aerial survey of the Hay's Canyon area (sponsored by NBU, Reno) immediately following the discovery of the first dead ewe. Only seven live sheep were seen. Increasingly intensive ground surveys in October and November followed and during this time, NDOW biologists and dedicated NBU members spent time in the mountains on foot and were able to locate several decomposed carcasses as well as several sick bighorn sheep. Through the cooperation of NDOW and NBU, a number of valuable samples were obtained from both sick and dead animals.

As expected, bacterial pneumonia was identified in all animals but a very interesting finding consistent among many of these animals was that the pneumonia was apparently caused by *Pasteurella multocida* U<sup>6</sup>. *Pasteurella* is one class of bacteria commonly seen in sheep with pneumonia and it's been well established that certain species can cause disease in bighorns. The species *P. multocida* however is not ordinarily associated with disease in bighorn sheep, but this particular biotype is known to have been a factor in other bighorn die-offs in other areas. For example, the same bug was cultured in high numbers from free-ranging bighorn sheep in the Hells Canyon area of Idaho, Washington, and Oregon during the winter of 1995-96 following a major die-off. Animals captured in Hells Canyon and held in captivity, and their offspring, also harbored *P. multocida* U<sup>6</sup>.

All evidence gathered in the fall of 2007 pointed to a die-off occurring in the area and a second helicopter survey was conducted by NDOW in mid-November covering the entire ridge system and western slope of the Hay's Canyon Range. The survey turned up more carcasses and only two bighorn were seen alive. Several bighorn observed alive during the initial helicopter survey in October were later found dead near or adjacent to water sources.

Additional ground surveys failed to locate any live bighorn; however, three sets of fresh bighorn tracks were observed near the lower big game guzzler in late November. As a result, a remote camera was positioned at the guzzler in an attempt to document the presence of live bighorn; unfortunately, none was photographed during the 5 to 6 week period of observation. Ground surveys continued and focused on south slopes, open areas, and water sources on the western slope of the Hays Canyon Range. No live bighorn were observed but additional carcasses were located including the skull and remains of a 9-year-old ram located by a rancher near a spring source in early December. (NDOW 2008a, 1-2)

A detailed NDOW report on the Hays Canyon Range disease outbreak (quoted above) makes no reference to domestic sheep (2008a). However, in a March 2008 report, an NDOW veterinarian mentions that grazing permit holders were participating in the disease investigation (NDOW 2008b).

The NDOW indicated the pneumonia causal mechanism was a mystery and stated: “Unfortunately it may be some time before we have a good understanding of the factors that initiated this disease event . . . . Respiratory disease in bighorn sheep is especially complex, usually involves multiple factors and specific causes can be very difficult to determine” (2008a, 3). They added: “We hope soon to be able to shed light on what may have contributed to these disease events. Since early spring, ground investigations have taken place and several reliable reports of a small number of live bighorn sheep have been received” (2008a, 3).

In its 2007-2008 big game status report, NDOW stated: “It is still possible that there are bighorn that survived the disease event” (NDOW 2008c, 80). However, in its status reports published from 2009-2012, NDOW neglected to even mention the Hays Canyon Range (NDOW 2009, 2010, 2011, 2012a). There have been no confirmed, documented sightings of bighorns in the Hays Canyon Range since the 2007 die-off (Dobel 2012a). An examination of policy documents reveals insights on regulations that

may have prevented the obliteration of the Hays Canyon Range's bighorns if they were followed more closely.

### Policy Documents

The BLM's May 2007 Surprise PRMP describes many wild-domestic sheep interaction policies applicable on a location-specific level to the Hays Canyon Range (BLM 2007a). This document was completed just prior to the fall 2007 pneumonia outbreak, so it provides insights on agency tendencies at the time. However, a record of decision (ROD) for that PRMP was not published until April 2008 (BLM 2008). The ROD "links final land use plan decisions to the analysis presented in the Proposed RMP/Final Environmental Impact Statement (FEIS)" (BLM 2008, 2).

One item that stands out in the PRMP (and contrasts with reputable scientific consensus) is a response to a public comment questioning the validity of the concept of domestic sheep transmitting disease to bighorns. Part of the BLM's response was: "The scientific evidence regarding the susceptibility of bighorn sheep to disease transmitted by domestic sheep is still open for debate" (BLM 2007a, A-139).

Additionally, the PRMP states that the "BLM's [1998] *Revised Guidelines for Managing Domestic Sheep and Goats in Wild Sheep Habitats* . . . would provide operational guidance for domestic sheep and goat management in the SFO [Surprise Field Office]" (2007a, 2-37). The PRMP also states that "regarding elimination of domestic sheep in areas used by bighorn sheep," the BLM will use those guidelines (BLM 2007a, A-249). A BLM resource management plan for the Challis area in Idaho provides background on the 1998 guidelines:

These guidelines . . . were included as Attachment 1 to BLM Instruction Memorandum No. 98-140 (July 10, 1998). The 1998 revised guidelines were



developed following a review of the 1992 Guidelines for Domestic Sheep Management in Bighorn Sheep Habitats (Instruction Memorandum 92-264) in June 1997, and a follow-up meeting of bighorn and domestic sheep specialists in April 1998. Instruction Memorandum 98-140 state that these revised guidelines “should be followed whenever reintroductions, transplants, or augmentations of wild sheep populations, or proposed changes in a livestock grazing permit on BLM administered lands are being considered. . . .” (BLM 1999, 95)

Within the 1998 guidelines, the BLM added language providing enforcement flexibility:

. . . the guidelines . . . should be followed in current and future native wild/domestic sheep and goat use areas unless a specific cooperative agreement that includes the State wildlife management agency, the BLM and the livestock permit holder is in place. When such agreement is in place, the agencies and the livestock permit holder will be held harmless in the event of a disease impacting either native wild sheep or domestic sheep and goats. (BLM 1999, 95-96)

According to BLM biologist Scott Soletti: “A cooperative agreement was not in place for domestic sheep trailing in the Tuledad Allotment” (2012). Thus, management of the Tuledad domestic sheep should have followed the 1998 BLM guidelines. These guidelines are included as Appendix H at the end of this thesis.

The NDOW’s *Bighorn Sheep Management Plan: October 2001* is the main document pertinent to state wildlife agency policies in place at the time of the Hays Canyon Range outbreak (NDOW 2001). According to NDOW, that plan “is a guiding document for the Nevada Board of Wildlife Commissioners . . . and the Nevada Division of Wildlife . . . efforts in the conservation and management of bighorn sheep populations and their habitat” (2001, 2). Several NDOW plan statements are relevant to all policy analysis criteria in this study (2001).

One such statement is NDOW’s declaration that: “Domestic sheep operations pose the largest obstacle to the further expansion of bighorn sheep populations in the State of Nevada due to continued concerns over disease transmission” (2001, 8). The NDOW also remarks that: “The Division will encourage and support the management of

livestock when such management results in the attainment of land use goals and objectives consistent with wildlife needs. The Division should take appropriate action, including litigation, when these goals and objectives are not obtained” (2001, 12). The NDOW adds: “The Division will minimize domestic farm flock sheep/wild sheep interactions through all possible means. This could include entering into cooperative agreements with willing landowners, education, and cooperating with [the] Department of Agriculture” (2001, 21).

The NDOW did not state that it will adhere to or adopt the BLM’s 1998 guidelines, but the guidelines are listed in the plan’s “Appendix A: Laws and Regulations Pertinent to Bighorn Sheep Management” (2001, A-3). The NDOW also says it “may initiate a disease prevention or health enhancement program for a particular [bighorn] population if the costs and benefits are justified” (2001, 21). Additionally, regarding disease management strategies, NDOW states that “The Bighorn Sheep Interaction With Domestic Sheep and Disease and Health Assessment protocols will be followed” (2001, 21).

Now that background has been provided on the 2007 Hays Canyon Range bighorn disease outbreak and numerous factors related to it, context has been established for more fully understanding specific wild-domestic sheep policies in the area.

#### POLICY ANALYSIS CRITERIA

##### ***1.) Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?***

##### ***Answer and Explanation***

In the Hays Canyon Range, clearly defined buffer zones were not established in an effort to separate bighorns and domestic sheep (Flores, Jr. 2012). Bureau of Land

Management biologist Elias Flores, Jr. explains why the Surprise District did not have clearly defined buffers in 2007:

There were no “clearly defined” buffer zones in place. They are not required if adequate separation obstacles or distances or timing exists. Three allotments on the field office; Tuledad, Selic/Alaska, and Red Rock Lake are authorized for domestic sheep grazing. I had asked that the permittees inform the BLM when they would be trailing through the Tuledad allotment however it doesn’t look like it made it into the official, signed Annual Operating Plan. Without a large buffer distance, domestic and bighorn sheep could theoretically make nose to nose contact between the Tuledad and Duck Lake and Lower allotments (these last two being known bighorn areas) if domestic sheep were not closely watched and bighorn were in the area. (2012)

At the time of the 1989 establishment of bighorns in the Hays Canyon Range, there was no need for any type of agreement on buffers because bighorn range was isolated enough from domestic sheep that managers assumed a disease threat was not significant. In 1989, the Hays Canyon Range also hosted no active domestic sheep allotments (Dobel 2012a).

### Policy

According to the BLM’s 1998 guidelines, “native wild sheep and domestic sheep or goats should be spatially separated to reduce the potential of interspecies contact” (1999, 96). The BLM also remarks:

In reviewing new domestic sheep or goat grazing permit applications or proposed conversions of cattle permits to sheep or goat permits in areas with established native wild sheep populations, buffer strips surrounding native wild sheep habitat should be developed, except where topographic features or other barriers minimize physical contact between native wild sheep and domestic sheep and goats. Buffer strips could range up to 13.5 kilometers (9 miles) or as developed through a cooperative agreement to minimize contact between native wild sheep and domestic sheep and goats, depending upon local conditions and management options. (BLM 1999, 96)

In the 2007 Surprise PRMP, a “No Action Alternative” in a table regarding noxious and invasive weeds states: “A minimum nine mile buffer (or as developed

through a cooperative agreement) between domestic sheep, goats and bighorn habitat would continue to limit the use of sheep and goats as weed control agents . . .” (BLM 2007a, 2-144). In its 2006-2007 big game status report, regarding the Hays Canyon Range, NDOW states: “Future water developments built on the top of the rim will help keep bighorn away from the valley bottoms where domestic sheep are grazed and trailed” (2007, 72).

***2.) Were special supervision rules in place for sheepherders?***

*Answer and Explanation*

No location-specific special supervision rules existed that would encourage sheepherders to keep their flocks separate from bighorns (Flores, Jr. 2012). Flores, Jr. notes: “There is disagreement as to whether domestic sheep always have herders with them however on several occasions domestic sheep have been observed by both BLM and [NDOW] with no sheep herders” (2012). Dobel emphasized that domestic sheep can unexpectedly show up in certain areas (2012a).

*Policy*

The BLM’s 1998 guidelines state: “Domestic sheep and goats should be closely managed and carefully herded where necessary to prevent them from straying into native wild sheep areas” (1999, 96). The BLM adds: “Cooperative efforts should be undertaken to quickly notify the permittee and appropriate agency to remove any stray domestic sheep or goats or wild sheep in areas that would allow contact between domestic sheep or goats and native wild sheep” (1999, 96).

### ***3.) Were domestic sheep trailing restrictions in place to ensure separation?***

#### **Answer and Explanation**

No domestic sheep trailing restrictions were in place to ensure wild-domestic sheep separation (Flores, Jr. 2012). The BLM's 2007 operating instructions for the closest domestic sheep grazing allotment did not mention special trailing restrictions related to protecting bighorns (2007b). However, as mentioned in the explanation to criterion #1, the BLM did ask for notification for when domestic sheep trailing near bighorn habitat would occur (Flores, Jr. 2012).

#### **Policy**

The BLM's 1998 guidelines state: "Domestic sheep or goat grazing and trailing should be discouraged in the vicinity of native wild sheep ranges" (1999, 96). The BLM adds: "Trailing of domestic sheep or goats near or through occupied native wild sheep ranges may be permitted when safeguards can be implemented to adequately prevent physical contact between native wild sheep and domestic sheep or goats. BLM must conduct on-site use compliance during trailing to ensure safeguards are observed" (1999, 96).

At a BLM national policy level, NDOW participated in policymaking in which it was decided that BLM employees would monitor domestic sheep trailing to reduce the risk of disease transmission to bighorns. Such policy is quoted above. This policy (introduced in the early 1990s) was an attempt to pacify state game agencies.

Unfortunately, the policy did not have legal teeth, and according to at least one retired NDOW Game Bureau Chief, it was never enforced (Tanner 2012a). This correlates with the fact that the 2007 Tuleadad Allotment operating instructions document makes no

reference to special accommodations for bighorns in its directions for monitoring, trailing, or general sheep pasture use (BLM 2007b).

The Surprise PRMP says: “Trailing may be allowed in allotments closed to domestic sheep grazing in compliance with BLM’s ‘Guidelines for Managing Domestic Sheep and Goats in Wild Sheep Habitats’” (BLM 2007a, 2-37). In a table describing domestic sheep grazing alternatives, for a “No Action Alternative” (current policy at the time of the Hays Canyon Range outbreak), the Surprise PRMP states that trailing of domestic sheep would be allowed “in [the] Tuledad, Selic-Alaska, and Red Rock Lake Allotments and in areas that are allotments  $\geq$  9 miles from occupied bighorn habitat” (BLM 2007a, 2-124).

***4.) Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?***

*Answer and Implementation*

Domestic sheep presence was directly addressed before bighorn reintroduction (Flores, Jr. 2012). Flores, Jr. explains how considerations were addressed prior to reintroducing bighorns to the Hays Canyon Range:

A Habitat Management Plan was developed (1989) between BLM, NDOW, Nevada Bighorn’s Unlimited and several local ranchers. Several factors including the die-off in early 1988 of bighorn in the Warner Mountains, led to the recommendation of reintroducing bighorn sheep into the entire Hays Range. The 1988 recommendation came about through a task force appointed by the Modoc/Washoe Experimental Stewardship Steering Committee. (2012)

*Policy*

Prior to the 1989 reintroduction of bighorns to the Hays Canyon Range, there was an internal NDOW policy not to release bighorns into areas hosting domestic sheep (Tanner 2012a).

***5.) Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?***

*Answer and Implementation*

One sheep allotment was converted to cattle (Flores, Jr. 2012). Flores, Jr. states: “Part of the task force [appointed by the Modoc/Washoe Experimental Stewardship Steering Committee prior to bighorn reintroduction] recommendation was that BLM convert sheep AUMs to cattle AUMs in the Bicondoa Allotment (Hays Range)” (2012). An examination of the latest Surprise PRMP shows that the Bicondoa Allotment was no longer a sheep allotment by 2007 (BLM 2007a).

*Policy*

The Surprise PRMP declares: “Voluntary changes or conversions of the permits from domestic sheep to cattle grazing provide the Surprise Field Office the opportunity to coordinate with state wildlife agencies and other cooperators in developing a reintroduction plan for California bighorn sheep prior to reintroduction efforts” (BLM 2007a, 2-37). The PRMP also remarks:

Grazing of domestic sheep would continue . . . unless in the future the current operator elects to convert the livestock kind from sheep to cattle or if the allotments are vacated for reasons unforeseeable at this time. Due to the interest of state game agencies to reintroduce bighorn back into the Warner Mountains, any subsequent request to convert permits from cattle back to sheep would be coordinated with livestock operators and state game agencies. (BLM 2007a, 2-37)

The Surprise PRMP would allow conversion of cattle allotments to sheep allotments “if [there is] low potential for direct contact between domestic sheep and bighorn” (BLM 2007a, 2-124).

The NDOW’s bighorn management plan states: “The purchase of conservation easements, property and associated grazing privileges, conversions of Animal Unit

Months (AUM's) from domestic sheep to cattle or water rights, will be done to protect or enhance important bighorn sheep habitat" (2001, 2). Further in the plan, NDOW uses somewhat looser language ("pursue" instead of "done") in a nearly identical statement (2001, 8). The NDOW adds: "Any AUM conversion, acquisition of private land, grazing privileges or easements will only be accomplished through a willing seller. The purchase of conservation easements and AUM conversions would be preferred over the purchase of property" (2001, 8).

***6.) Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?***

*Answer and Implementation*

Negotiation and education were attempted with local stakeholders, but such efforts were not always successful (Flores, Jr. 2012). Flores, Jr. notes that "any information has been met with great criticism. There is still local belief by producers that there is no issue of disease transfer between domestic sheep and bighorn sheep" (2012). Some of the livestock operators in the Hays Canyon Range area are especially irrational, and talking to them can be difficult. The NDOW engaged in cooperative efforts with the BLM in attempts to talk to livestock operators about the disease threat of domestic sheep. However, some forms of cooperation are at the will of particular stakeholders. There is only so much that agencies can do. Nonetheless, NDOW has had a pretty good working relationship with some sheep ranchers, including those who have owned sheep that got net-gunned and relocated by NDOW (Dobel 2012a).

*Policy*

In its bighorn management plan, NDOW regularly emphasizes the need for more public education on bighorns (2001). It remarks:



The desert bighorn sheep is Nevada's state animal; yet, the general public has very little knowledge about bighorn sheep. Therefore, the Division is challenged to increase public awareness and appreciation for bighorn sheep and their habitats in order to facilitate decisions favorable to their long-term well being. (NDOW 2001, 2)

The NDOW lists a management action to: "Continue to use all of the means available to educate the general public on issues pertaining to bighorn sheep and other wildlife" (2001, 29). It highlights a need for education to achieve both awareness and regulation compliance. The NDOW's bighorn education policies target students, the general public, and hunters (2001).

***7.) If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?***

*Answer and Implementation*

In 2000, this policy was implemented in northeastern California's Warner Mountains when a young bighorn ram was killed after he was seen with a group of domestic sheep (Meintzer 2009; Epps et al. 2003; Western Hunter 2000). This ram may have traveled from the Hays Canyon Range (BLM 2007a). Flores, Jr. was not aware of additional similar bighorn removals in the area (2012). Dobel also did not know of any more bighorn removal efforts in the Hays Canyon Range region. He noted that such removal was not really considered an option until recently (within the last five to six years) (2012a).

*Policy*

According to the BLM's 1998 guidelines: "Cooperative efforts should be undertaken to quickly notify the permittee and appropriate agency to remove any stray domestic sheep or goats or wild sheep in areas that would allow contact. . ." (1999, 96). As of 2008, NDOW endorsed the wandering wild sheep removal policy (Mack 2008).

**8.) *Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?***

*Answer and Nature*

Both coordination and tension existed (BLM 2007a; NDOW 2001; Soletti 2012; Flores, Jr. 2012). Some tension existed onsite. Regarding the Tuledad Allotment, Soletti stated that “in general there was a struggle to organize and maintain communications between the permittee and the BLM in regards to trailing sheep” (2012). Flores, Jr. provides more detail regarding onsite agency tensions:

There were differences of opinion during the RMP process as to where bighorn sheep should be. The California Department of Fish and Game had reservations concerning keeping domestic sheep in the three allotments listed above. Our guidance however is that BLM lands are to be managed for multiple resources. Having allotments open to both domestic and bighorn sheep falls within our multiple use mandates. In addition the BLM did not feel that having bighorn sheep in the south Warner Mountains was supportable given the number of domestic sheep in Modoc and Lassen counties as well as in Surprise Valley (also includes Washoe County). Also there had been a previous die-off (see above) and there were no other bighorn sheep populations in the general vicinity. NDOW generally supported the RMP but was in favor of modifying or removing the sheep permits to better protect bighorn in the Hays Range. (2012)

Coordination and tension also existed at the state level before the die-off. In the answers to a questionnaire presented to biologists at the 2nd North American Wild Sheep Conference in 1999 (Table 2.1 on page 52), Craig Mortimore provides details on California bighorn management in Nevada (Arthur et al. 1999). One question specifically regarding California bighorn management asks: “What are the 3 biggest challenges in your state/province regarding state/federal relationships and management of wild sheep?” (Arthur et al. 1999, 432). In response, Mortimore remarks that “NDOW has good relationships with USFS, USFWS, and BLM,” but he also lists “domestic sheep trailing” as a challenge (Arthur et al. 1999, 432).

### Policy

The Surprise PRMP policy mentions that allotment conversions would give the BLM the “opportunity to coordinate with state wildlife agencies and other cooperators” (BLM 2007a, 2-37). The PRMP also mentions cooperating “with state game agencies in construction of additional guzzlers east of Surprise Valley to discourage bighorn sheep from crossing to the Warner Mountains” (BLM 2007a, 2-123).

More references to coordination occur in the BLM’s 1998 guidelines, which note that: “State wildlife and Federal land management agencies, native wild sheep interest groups, and domestic sheep and goat industry cooperation and consultation are necessary to maintain and/or expand native wild sheep numbers” (1999, 96). The BLM also indicated that their 1998 guidelines do not have to be followed if “a specific cooperative agreement that includes the State wildlife management agency, the BLM and the livestock permit holder is in place” (BLM 2007a, 95).

In its 2001 bighorn management plan, NDOW states: “Since most . . . bighorn sheep habitat is managed by the Bureau of Land Management, the U.S. Forest Service, the U.S. Fish and Wildlife Service, the National Park Service, military installations, Indian Tribes, and private landowners, it is imperative that the Division always strive for cooperation and collaboration with these entities” (2001, 6).

### ***9.) Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?***

#### Answer and Nature

Funding difficulties were not in issue in the area (Flores, Jr. 2012; Dobel 2012a). Dobel could not recall any funding difficulties regarding wild-domestic sheep management in the Hays Canyon Range. He emphasized that within the realm of the

disease issue, politics is more important than money (2012a). Flores, Jr. explains the nature of funding bighorn management in the Hays Canyon Range:

There have been no projects brought forth by the BLM (other than habitat projects) that would require additional funding. BLM has worked with NDOW to support building/maintenance of bighorn sheep guzzlers or to have guzzlers filled during drier seasons. The BLM is currently working with NDOW to identify areas for fencing to reduce the possibility of contact between domestic and bighorn sheep. The BLM has acquired additional bighorn habitat through acquisition funding however these were not specifically for bighorn sheep. The BLM does not anticipate funding difficulties related to bighorn sheep. (2012)

### Policy

Regarding bighorn habitat acquisition, land protection, and grazing allotment conversions, NDOW stated in its bighorn management plan that: “Funding sources could include mitigation from urban sprawl (such as Southern Nevada Public Lands Management Act), conservation organization partnerships, heritage account, bond revenues and federal aid” (2001, 8).

### **Policy Efficacy Summary**

Regarding the wild-domestic sheep management situation in the Hays Canyon Range prior to 2007, agency neglect and ineffective policy implementation stand out. Location-specific bighorn-domestic sheep interaction policies actually implemented before the 2007 die-off did not include clear buffers, special sheepherder supervision rules, or trailing restrictions (Flores, Jr. 2012). However, all these policies were in print before the outbreak (BLM 1999) and could have been applied to the Hays Canyon Range. The fact that the BLM chose not to enforce these policies reflects ineffective handling of policies that may have been effective if they were actually implemented.

The consideration of domestic sheep before bighorn reintroduction and the alteration of a grazing allotment (Flores, Jr. 2012) reflect some policy efficacy and may

have delayed a bighorn die-off in the Hays Canyon Range. However, domestic sheep consideration and grazing allotment alteration were too limited in scope, which made such policies ineffective in the long-term. Education and negotiation were attempted (Flores, Jr. 2012), but they were largely ineffective because of science denial from local sheep producers. In 2000, one bighorn (likely from the Hays Canyon Range) was removed from the wild after being seen near domestic sheep (Meintzer 2009; Epps et al. 2003; Western Hunter 2000). This removal may have been effective at delaying disease.

Coordination and tension were involved with managing Hays Canyon Range sheep. During the planning process for reintroducing sheep to the range, conflict existed between the BLM (which wanted to continue domestic sheep grazing in the area) and CDFG and NDOW (which had some bighorn-related concerns regarding nearby domestic sheep allotments) (Flores, Jr. 2012). This conflict contributed to the imperilment of Hays Canyon Range bighorns. It also illustrates wildlife federalism complications making policy more ineffective because it shows that in some instances, state governments may be more apt to take actions that are in the best interest of bighorns while federal agencies may disagree and supersede state preferences with harmful policies. If CDFG and NDOW had more influence over the BLM, or if better cooperation occurred, domestic sheep may not have been grazed on the Tuledad Allotment after bighorns were reintroduced, which could have prevented a die-off. Considering the fact that thousands of domestic sheep were authorized to graze near the Hays Canyon Range (BLM 2007b), a bighorn die-off seemed all but uncertain. In the Hays Canyon Range, politics proved to be a stronger influence on policy than funding, which was not a significant issue (Dobel 2012a).

## **SECTION 6 – BONNER/WEST RIVERSIDE, MONTANA: 2010**

### *Introduction*

Rocky Mountain bighorns in the Bonner/West Riverside population live near the adjacent communities of Bonner and West Riverside (46° 52' 39.93"N, 113° 53' 20.00"W), which are located in west-central Montana about 6 km (4 mi) northeast of Missoula in Missoula County (MFWP 2010a; Google Earth 2012). Bonner/West Riverside bighorns range within state Bighorn Hunting District 283 (Lower Blackfoot), which contains about 579 km<sup>2</sup> (360 mi<sup>2</sup>) (MFWP 2010a). The MFWP provides a description of this region:

Plum Creek Timber Company (PCT) owns approximately 24%, the U.S. Forest Service (USFS) – Lolo National Forest (NF) administers about 37%, and the State of Montana administers 5% of the hunting district. The remaining [34%] is privately owned. The quality and quantity of winter range forage here is declining. Grasslands are subject to weed infestations and conifer encroachment. Shrubfields, created by the wildfires in the early 1900s, are decadent and degraded by conifer reproduction.

Approximately 25 mi<sup>2</sup> (7%) of the hunting district are occupied by bighorn sheep during some portion of the year. Forty-five percent of the occupied range is on public lands. [Bighorn] sheep commonly graze in residential lots in the West Riverside community. The bighorn sheep population is commonly referred to as the “Bonner herd” because it is generally limited to suitable habitats in the lower Blackfoot River drainage near the town of Bonner. (2010a, 168)

Just prior to the outbreak they experienced in 2010, Bonner/West Riverside bighorns were “well established in all suitable habitats” (MFWP 2010a, 169). The MFWP adds:

In addition to the core population that inhabits the area north of Bonner and the Blackfoot River, a subpopulation of approximately 30 (not surveyed) occupies a portion of the Rattlesnake Wilderness and National Recreation Area. Another subpopulation of approximately 30 (not surveyed and not hunted) occupies the area south of the Blackfoot River between Bonner and LaFrey Creek in Hunting District 292. During cold winters, sheep often cross an iced-over Blackfoot River . . . . Occasionally, bands of young rams and/or ewes are seen on Mount Jumbo

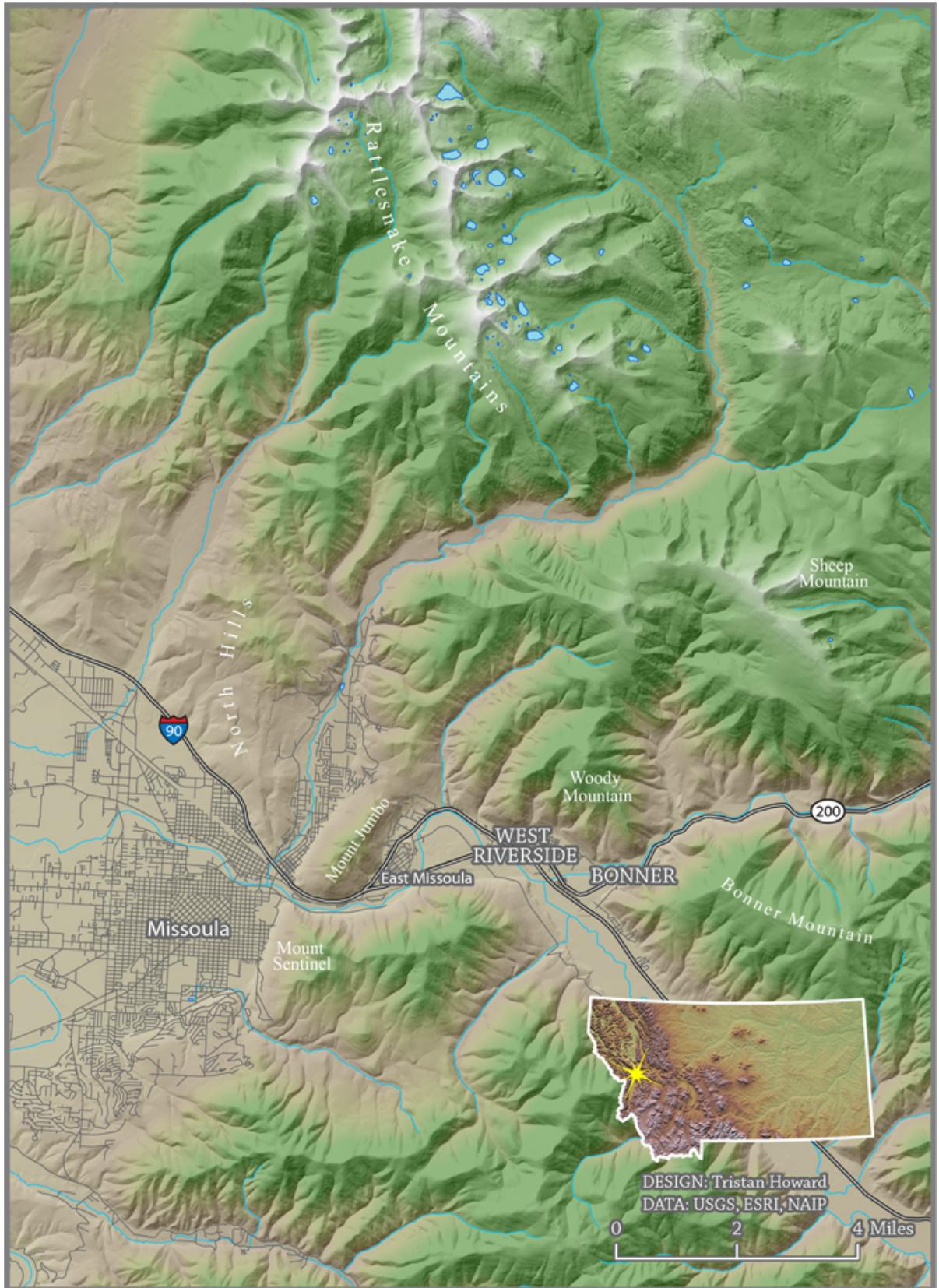


Figure 4.11. Bonner/West Riverside terrain.



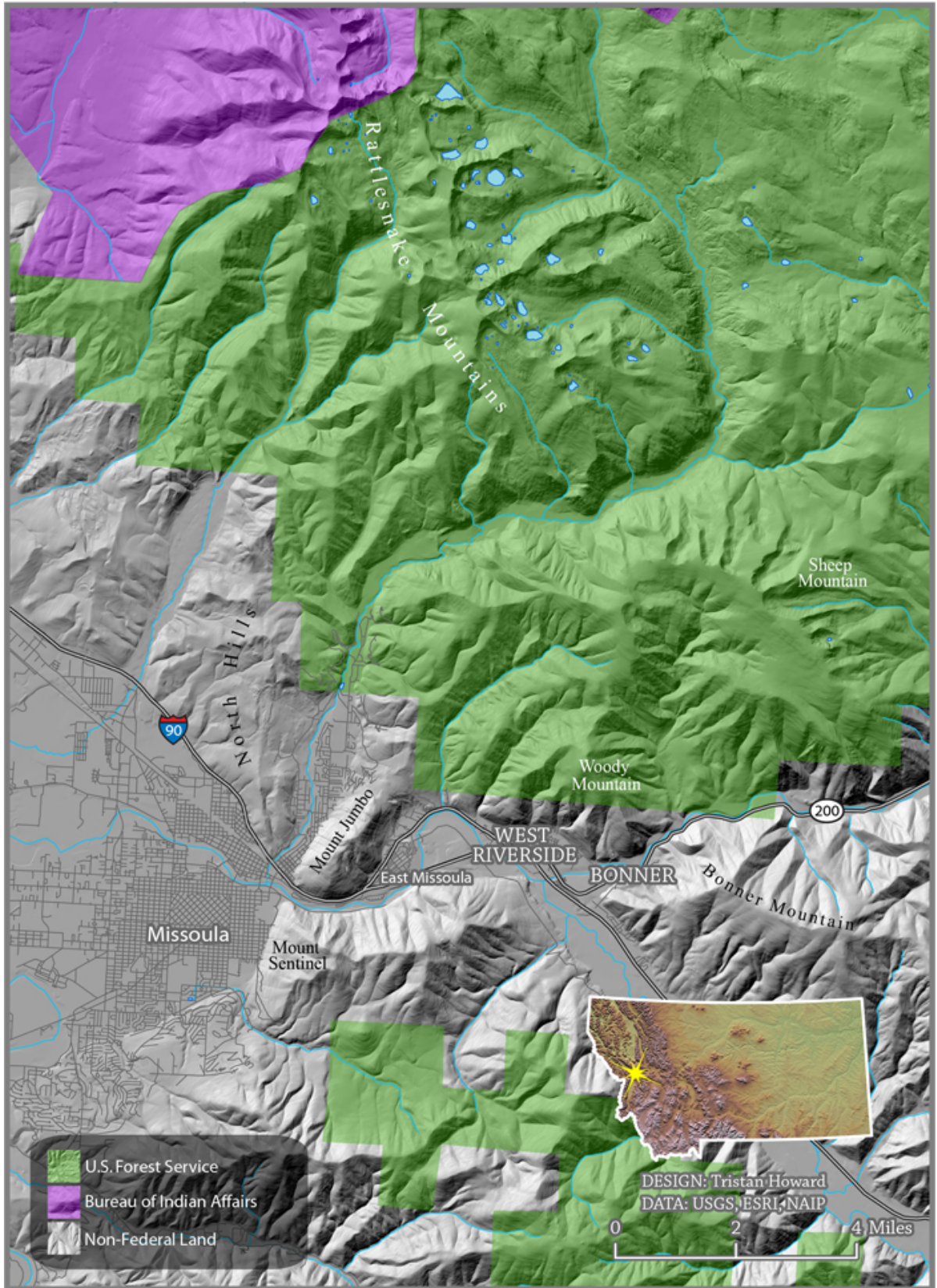


Figure 4.12. Bonner/West Riverside federal land ownership.



and near Johnsrud Park in Missoula, suggesting that surplus animals are immigrating in search of new habitats or other bighorn populations.

In 2008 and 2009, TNC [The Nature Conservancy] purchased 12,305 acres within the hunting district from PCT as part of the Montana Legacy Project. In 2009, TNC turned 5,169 acres over to the Lolo NF. The majority of those lands include important occupied bighorn sheep winter habitat northeast of Bonner. (2010a, 169)

Montana wildlife managers reestablished Rocky Mountain bighorns in the Bonner/West Riverside area in 1987 (MFWP 2010a). The bighorns spent time near subdivisions that hosted hobby flocks of domestic sheep, and wild-domestic interaction was observed in fall 2009 (Edwards et al. 2010). This mingling may have contributed to a 2010 pneumonia outbreak that led to the deaths of about 100 bighorns (WAFWA 2010c). Various documents shed light on policy that addressed wild-domestic sheep interaction in the Bonner/West Riverside area before it experienced a disease outbreak. These documents include Montana's 2010 bighorn management plan and an agreement between MFWP and The University of Montana (UM) (MFWP 2010a; TUM 2001).

Regarding bighorn-domestic sheep interaction policies, Bonner/West Riverside lacked clear buffers, had special supervision rules for sheepherders, and did not have trailing restrictions (Edwards 2012; TUM 2001; MPRD 2010; Stockman 2012). Montana wildlife managers considered domestic sheep presence before reintroducing bighorns to the area, and grazing allotment alterations were not attempted because there were no federal domestic sheep grazing allotments in the area (MFWP 1986; Stockman 2012). Negotiation or education were attempted, and bighorns near domestic sheep were removed from the wild (MFWP 2010a). Agencies also coordinated and did not experience significant tension or funding difficulties related to the wild-domestic sheep disease issue (TUM 2001; MPRD 2010; MFWP 2010a; Canepa 2012; Valliant 2012).

Before examining policies in more detail, it helps to know more about the history of bighorns in the Bonner/West Riverside area.

*Bighorn Population History Prior to Outbreak*

In 1987, MFWP reestablished bighorns in the Bonner region by transplanting 14 animals from Upper Rock Creek to Woody Mountain. In 1990, wildlife managers augmented this population with 30 additional bighorns from the Sun River population (MFWP 2010a). According Edwards et al.: “Bighorns soon became well established in all suitable habitats near the community of Bonner” (2010, 32). Regarding population dynamics, MFWP states:

During good years, recruitment may be 40 to 55 lambs:100 ewes recorded during early April surveys. But lamb:ewe ratios have often been below 35:100 and in 1998, following the 1996-97 winter, only 13 lambs:100 ewes were observed. . . .

Because of the lack of hunting access that might otherwise control this population and because of the numerous complaints from residents in West Riverside, FWP repeatedly has trapped and removed sheep for starting or augmenting other herds. The 1996 to 97 winter was so severe that more than 30 sheep were forced to temporarily live in the Big Pine Trailer Court until FWP trapped and successfully translocated 31 of them to the Elkhorn Mountains. In 2007, another 27 sheep were captured and moved to Utah. (MFWP 2010a, 169)

Edwards et al. remark: “Human-bighorn conflicts were especially prevalent in the West Riverside community where  $\geq 98$  bighorns grazed on residential lots” (2010, 33). The Bonner/West Riverside bighorns became “a popular watchable wildlife opportunity because of [their] proximity to Missoula and Bonner and MT Highway 200” (MFWP 2010a, 169). In 1996, a hunting season on these wild sheep started (MFWP 2010a). In 2000, two yearling bighorn rams from the Bonner/West Riverside population had made their way to Mount Jumbo where they were shot after being observed near domestic sheep used for weed control (MFWP 2010a; TUM 2001). In 2007, a helicopter survey counted 128 bighorns in the Lower Blackfoot Bighorn Hunting District (MFWP 2010a).

By late 2009, the population consisted of about 160-180 bighorns (WAFWA 2010c).

Though well-established in the area, bighorns were not the only sheep in what are literally the Bonner/West Riverside neighborhoods.

#### Nearby Domestic Sheep

Before and after the outbreak, known association between bighorns and domestic sheep or goats occurred (WAFWA 2010c). Edwards et al. explain:

Numerous domestic sheep and goats were present for many years as hobby flocks and commercial operations, but there had been no previously known incidence of pneumonia in the Bonner population. After the die-off was detected in January 2010, the public reported a case of bighorns and domestics comingling in the fall of 2009. (2010, 33)

In addition, MFWP states: “Rural subdivisions in the East Missoula and Bonner areas have resulted in small bands of livestock including domestic sheep and goats” (2010a, 170). Before the outbreak, domestic sheep were also used by the City of Missoula for local weed control—with some of them grazing on Mount Jumbo at the edge of town (WAFWA 2010b; MFWP 2010a). However, Missoula does not graze domestic sheep on Mount Jumbo in January, which was when disease hit the Bonner/West Riverside bighorns (Stockman 2012). Additionally, an inquiry to the Lolo National Forest reveals that “the Missoula Ranger District did not graze sheep or goats in 2010 in the Bonner area” (Stockman 2012). With domestic sheep largely absent or closely regulated on public lands, subdivision animals may have caused the bighorn disease outbreak in the Bonner/West Riverside area.

#### Outbreak Summary

In the winter of 2009-2010, Rocky Mountain bighorns in the vicinity of Bonner/West Riverside experienced a pneumonia outbreak (WAFWA 2010c). On

January 12, 2010, residents in the Bonner area “reported coughing/sick [bighorns] in/near subdivisions” (WAFWA 2010b, 1). Approximately 110 estimated mortalities occurred. Of these, 99 deaths resulted from culling performed by MFWP in an effort to prevent further disease spread (WAFWA 2010c). West Riverside residents cooperated with MFWP during culling efforts (MFWP 2010b).

The MFWP shot many bighorns in mountains north of the Blackfoot River (Chaney 2010). Biologists employed a containment zone strategy and killed bighorns that left a certain area (Gevock 2010). The containment zone included “the West Riverside and Bonner communities and land lying between Marshall Canyon and about two miles east of Johnson Gulch” (MFWP 2010b). Wildlife managers hoped to prevent the spread of pneumonia to more isolated bighorns inhabiting the Rattlesnake Wilderness and regions southeast of Bonner along Highway 200 (Chaney 2010; MFWP 2010b). In addition to the 99 documented culling deaths, Bonner/West Riverside bighorns also suffered four more known disease-related mortalities. In all, in the winter of 2009-2010, about 68 percent of the local population died because of the pneumonia outbreak (WAFWA 2010c).

The MFWP’s culling efforts appeared to achieve compensatory mortality—killing animals that would have died anyway. March-April 2011 bighorn population surveys showed the Bonner/West Riverside population (heavily culled) was 58 percent smaller than pre-outbreak numbers (Crowser 2011). The nearby Lower and Upper Rock Creek populations were also infected with pneumonia during the winter of 2009-2010 but were in an area “where intensive killing of diseased sheep was not feasible” (Crowser 2011, 2). The Rock Creek populations were 59 percent smaller than pre-disease numbers—about

the same percent reduction as Bonner. However, Bonner/West Riverside lamb recruitment for 2011 was the same as recruitment levels in spring 2009 before the die-off: 31 yearlings per 100 ewes (Crowser 2011). In the Rock Creek populations, “[2011] numbers of yearlings per 100 ewes declined by 96 percent since the die-off” (Crowser 2011, 2). So, in the case of the Bonner bighorns, culling likely helped reduce lamb recruitment suppression. Nonetheless, just what policy documents were in place that could have prevented the need to intentionally kill scores of bighorns?

### Policy Documents

Montana’s 2010 *Bighorn Sheep Conservation Strategy* was released in January—the same month managers noticed the Bonner/West Riverside outbreak. The 2010 document is Montana’s first comprehensive bighorn management plan (MFWP 2010a). According to the plan, “[bighorn] herd health currently is focused on maintaining separation between wild sheep and domestic sheep and goats to prevent potential disease transmission” (MFWP 2010a, 2).

As part of the plan’s “Statewide Protocol for Resolving Situations Where Bighorn Sheep and Domestic Sheep and Goats Commingle,” MFWP states:

If bighorns are using pastures common to domestic sheep and goats, every effort should be made to discourage animals from commingling. This is especially true in situations where bighorns are just beginning to move onto cultivated lands where contact with domestics could occur over time. (2010a, 50)

The MFWP based its separation policies on the Western Association of Fish and Wildlife Agencies’ (WAFWA) 2007 recommendations (MFWP 2010a; WAFWA 2007).

The excerpt below provides detail on MFWP’s attitude toward separation policies:

FWP believes that any localized removal, transfer, or conversion of established domestic sheep allotments on public lands for the benefit of bighorns should only come with the willing participation of the producer and land managing agencies.

FWP has spent much time listening to all sides of this issue and while it is FWP's direction to see bighorn sheep populations expand in distribution and numbers, as a wildlife-managing agency FWP readily acknowledges the contribution of livestock producers in providing valuable wildlife habitat and wildlife presence on their private lands. Additionally, something heard repeatedly in conversations with livestock producers was their desire to see viable populations of bighorn sheep in Montana. That feeling appears not to be held universally across the west where these domestic and wild species come together. (2010a, 3)

This attitude can be partially explained by the fact that Montana state code prohibits transportation of wildlife that could threaten agriculture (MFWP 2010a). The MFWP adds:

Although the Bighorn Sheep Conservation Strategy will serve as a source of information and guidance to the FWP Commission, it does not preempt Commission authority to formulate annual rules, augment or transplant, set hunting seasons and regulations, or implement emergency actions in response to unexpected events or circumstances. (2010a, 4)

So, regarding wild-domestic sheep interaction management, Montana's bighorn plan is more of a compilation of aspirational goals and guidelines instead of a binding document. Still, keeping in mind wildlife federalism, and the erosion of the state wildlife ownership doctrine, the federal government could make such guidelines more binding if it so chose.

Another important document regarding wild-domestic sheep interaction policy in the vicinity of the Bonner/West Riverside wild sheep population is the "Bighorn Sheep and Domestic Sheep Interaction Protocol" appendix in the *Missoula Conservation Lands Management Plan*. The protocol is an August 2010 update to the original protocol from 2000. The protocol addresses the City of Missoula's efforts to control invasive weeds on open space lands with domestic sheep grazing. It provides background on interaction policies in the decade before the outbreak (MPRD 2010).

The 2000 informal agreement and protocol was between MFWP and UM, which ran sheep vegetation management at the time. In 2005, the Missoula Parks and

Recreation Department (MPRD) took over sheep weed control efforts and coordinated with MFWP to limit bighorn-domestic sheep interactions on city open space lands (MPRD 2010). According to MPRD: “The City currently uses sheep to graze spurge and toadflax infestations on steep terrain on Mt. Jumbo and Waterworks Hill where few other weed control options are available” (2010, 120). Grazing times are adjusted based on timing of bighorn sightings on Mount Jumbo (Edwards 2012). The MPRD adds:

Although Jumbo, Sentinel and Waterworks Hill are not within bighorn sheep spring and summer ranges, wild sheep have been seen occasionally in these areas over the past 15 years. Most often, those sightings occurred from May-July and primarily involved dispersing subadult rams looking for other sheep and new habitats to colonize. (2010, 120)

The original 2000 protocol appears in a 2001 vegetation management plan for conservation lands in Missoula (TUM 2001). Some key general provisions of the protocol (that do not cleanly fit into the following policy analysis criteria) are below (TUM 2001, 21).

- We [MFWP] recognize that different situations will require different solutions. For example, close proximity to bighorns and domestics will necessitate permanent removal of the individual bighorns from the wild. Observations of wide separations (>1/4 mile) between the two species may only dictate prompt removal of the domestic sheep, until the bighorns leave. Other circumstances will be less clear, and we will have to use our best judgement. Good decisions will be best aided by the accurate and prompt reporting of each circumstance.
- If, over the years, bighorn sheep sightings become more common at one of these sites, suggesting a natural range expansion, the domestic sheep grazing program should be re-evaluated.
- In the event that a bighorn sheep die-off occurs at Bonner or in Lower Rock Creek, the domestic sheep grazing program should be re-evaluated.

The 1986 *Lolo National Forest Plan* was applicable at the time of the outbreak (USFS 1986b). Though the Lolo National Forest currently addresses the disease issue, an

examination of the plan reveals no reference to bighorn-domestic sheep disease (Stockman 2012; USFS 1986b).

Now that the Bonner/West Riverside disease outbreak and some of its related factors have been summarized, sufficient context has been established to examine individual policies.

#### POLICY ANALYSIS CRITERIA

##### ***1.) Were clearly defined buffer zones established to ensure separation of bighorns and domestic sheep?***

##### *Answer and Explanation*

Clear buffer zones were not in place in the Bonner/West Riverside area. Domestic sheep may not have been a significant location-specific concern at the time of the transplant. Bonner/West Riverside bighorns shifted primary habitat use away from the area where they were originally transplanted. The original transplant site (Woody Mountain) did not host domestic sheep, and the bighorns' habituation to subdivisions and people may not have been anticipated (Edwards 2012).

##### *Policy*

According to Montana's bighorn plan, "FWP has tried to establish a buffer zone of up to nine miles between domestic sheep and goats and bighorn sheep populations" (MFWP 2010a, 44). In the Montana bighorn plan's section covering "Suggested Management Practices on Private Lands," MFWP provides detailed recommendations for fencing that could help implement separation (2010a, 54).



## ***2.) Were special supervision rules in place for sheepherders?***

### **Answer and Implementation**

Special supervision rules for sheepherders were clearly in place in the Bonner/West Riverside area (TUM 2001; MPRD 2010). According to the Mount Jumbo Advisory Committee (MJAC):

Bighorn sheep arrived on Mount Jumbo in June 2001 at precisely the same time as in 2000. This year, the herder notified Marilyn Marler [Parks Department Advisor] immediately and the domestic sheep were removed from Mount Jumbo. As a result of this prompt action, there was no need for a removal of wild bighorn sheep from Mount Jumbo. (2001)

In June 2012, UM natural areas specialist Marilyn Marler stated: “My understanding is that the arrival date of the Mt Jumbo bighorns was very predictable, and now the sheep are just regularly moved prior to that date. Staff are still instructed to keep an eye out for big horns” (2012).

Morgan Valliant (Conservation Lands Manager for MPRD) provided the details that follow. In 2000, Missoula sheep managers had a part-time herder and a couple of volunteers keep an eye on domestic sheep from 7:00 a.m. to 8:00 p.m. By then, sheep supervisors already had cell phones and knew what bighorns looked like. However, they did not know about disease transmission. Cell phones had already been in use by the time of the 2000 bighorn euthanizations on Mount Jumbo. In 2000, several hours also passed on some days with no herders supervising sheep. After 2000, land managers hired three part-time herders to allow for better supervision. At least one herder was on-site every hour from 7:00 a.m. to 8:00 p.m. However, this supervision scheme was not a 24-7 process. The current sheep supervision program started in 2006, and it features one herder who is on-site 24-7 (Valliant 2012).

### Policy

In its bighorn management plan, MFWP emphasizes that those responsible for overseeing domestic sheep should quickly notify the agency if interaction with bighorns occurs (2010a). According to MFWP: “In areas where bighorn sheep and domestic sheep or goats share range or contact is possible, formal agreements between FWP and the producer/owner will be drafted outlining response plans should contact occur” (2010a, 49).

A 2000 bighorn-domestic sheep interaction protocol covering the Mount Jumbo weed control situation was in place at the time of the 2010 outbreak (MPRD 2010).

Below are key supervision policies from that protocol (TUM 2001, 21).

- Train herders to recognize bighorn sheep and describe circumstances of bighorn sightings. Their reports will be critical to the decisions we [MFWP] have to make.
- Provide herders with trained herding dogs, good sheep-holding facilities, and training for controlling domestic sheep. Loose sheep, out of control, are more likely to contact bighorns.
- Provide herders with cell phones. Observations of bighorns need to be reported to the Noxious Weed Coordinator and FWP, as soon as possible.
- Herders and owners need to be ready to remove domestic sheep from the site, as soon as bighorns are sighted in the area. Included should be the necessary equipment and alternate grazing sites. The longer the domestics are on site, the greater is the risk.

### ***3.) Were domestic sheep trailing restrictions in place to ensure separation?***

#### Answer and Explanation

Domestic sheep trailing restrictions were not in place (TUM 2001; Stockman 2012). The 2000 bighorn-domestic sheep separation protocol for Missoula’s open space lands does not mention sheep trailing. Also, domestic sheep on Missoula’s open space lands were not in the typical range of the Bonner/West Riverside bighorns, so they would

not have been trailed through regularly occupied bighorn habitat (TUM 2001).

Additionally, in 2010, the Missoula Ranger District of the Lolo National Forest did not graze domestic sheep in the Bonner region (Stockman 2012). Valliant adds: “No trailing restrictions. [There were] slim chances of seeing bighorns when we would walk sheep through the neighborhoods in the Lower Rattlesnake. I could see how this would be important when trailing through wildlands” (2012).

***4.) Were policies in place or was consideration taken regarding the concept of prohibiting bighorn reintroduction to the site if it hosted domestic sheep?***

Answer

Policies were in place that considered domestic sheep presence in an area prior to bighorn reintroduction (MFWP 1986).

Policy

In October 1986—just prior to the 1987 establishment of the Bonner/West Riverside bighorn population—MFWP approved guidelines for bighorn transplants (MFWP 2010a). One criterion of the 1986 guidelines was that: “Preference will be given those sites not in close proximity to domestic sheep and those with limited competition from other livestock or wild ungulates” (MFWP 1986, 2). Among components for determining transplant priority, the guidelines also list: “An evaluation of potential competition with domestic stock and other wildlife including the potential for disease transmission” (MFWP 1986, 1).

***5.) Before the disease outbreak, was any effort made to buy out nearby domestic sheep grazing allotments or convert them to cattle?***

***Answer and Explanation***

This criterion is not applicable because, in 2010, the Missoula Ranger District of the Lolo National Forest did not graze domestic sheep in the Bonner region (Stockman 2012).

***6.) Were other forms of negotiation and/or education attempted with local stakeholders regarding the issue of bighorn-domestic sheep disease transmission?***

***Answer***

Negotiation and education efforts regarding wild-domestic sheep separation have been carried out in the Bonner/West Riverside area (MFWP 2010a).

***Policy and Implementation***

A habitat management strategy for the hunting district containing the Bonner/West Riverside bighorns is to “continue to work with private landowners and Missoula County to limit the use of domestic sheep and goats in the area” (MFWP 2010a, 171). According to MFWP, “Missoula County has adopted covenants prohibiting domestic sheep in two subdivisions, but enforcement is typically left to homeowners” (2010a, 170). A July 2005 approval letter for the Quiet Pines Lots subdivision notes: “Domestic sheep and goats are not allowed in this subdivision because of the proximity to the Bonner bighorn sheep herd. The possibility exists that domestic sheep or goats could transmit a potentially fatal bacterial infection to bighorn sheep, leading to heavy mortality in the native bighorns” (Missoula County 2005b, 4).

This provision is part of MFWP’s “Living with Wildlife” covenants (Missoula County 2005a). The same covenant as above or covenants using nearly identical

language restricting domestic sheep because of Bonner/West Riverside bighorns appear in regulations for the Blackfoot Acres, Shadow Mountain Estates, and 20895 East Mullan Road subdivisions (Missoula County 2005a, 2006, 2007).

The MFWP's "Living with Wildlife" covenants are difficult to enforce, but Missoula County can enforce covenants via conditional approval of projects (e.g., a proposed subdivision may need to have domestic sheep restrictions to be approved). The County is aware of the wild-domestic sheep issue and generally takes the lead of MFWP. Missoula County tends to address bighorn-domestic sheep interaction covenants on a case-by-case basis based on MFWP's recommendations. However, the County does not have a specific policy for reviewing domestic sheep presence in bighorn habitat subdivisions (Canepa 2012).

While MFWP provides feedback on major subdivisions, minor subdivisions in Missoula County can escape wildlife agency scrutiny. Among numerous exceptions, minor subdivisions do not have to undergo public hearings or be reviewed for their impacts on the natural environment, wildlife, or wildlife habitats (Missoula County 2010).

In terms of review for bighorn-domestic sheep conflict, some minor subdivisions may slip through the cracks. The MFWP does not have time to review everything (Canepa 2012). However, in the Missoula area, MFWP still receives notifications when minor subdivisions are proposed for bighorn habitat. Personnel do not always have time to comment, but in the Missoula region, subdivisions in bighorn habitat get a red flag at the regional MFWP office (Edwards 2012). The MFWP has talked to the County about whether or not maintaining the Bonner/West Riverside bighorn population is worth the

effort because of the high risk of disease transmission from various private land animals (Canepa 2012).

In addition to weighing in on subdivision proposals and potential covenants, MFWP also developed education recommendations for those who control noxious weeds with domestic sheep or goats (MFWP 2010a). In its bighorn management plan, MFWP says it “will provide educational information and offer assistance to county weed districts regarding the disease risks associated with domestic sheep and goat use” (2010a, 52). The MFWP developed a wild-domestic sheep interaction protocol (for use with UM) that was in place during the 10 years leading up to the disease outbreak. Some key education provisions from that protocol are below (TUM 2001). Regarding whether or not these types of education efforts had actually been implemented in Missoula’s open space lands, Valliant remarked that there were: “No education efforts I recall” (2012).

- Use public education (i.e., Signs at trailheads, personal contact with recreationists, and newspaper articles) to inform the citizenry of the risks (both from the lack of weed control and pneumonia). People need to know the issues and how we are addressing them.
- Ask recreationists to immediately report sightings of wild sheep in the vicinities of Jumbo, Sentinel, and Waterworks Hill. Those sightings can be our early warning system.

Negotiation and education-related tasks are a major part of Montana’s “Statewide Protocol for Resolving Situations Where Bighorn Sheep and Domestic Sheep and Goats Commingle.” The MFWP explains:

It is the responsibility of each FWP region, where bighorn sheep occur to make the details of this protocol known to producers, managing agencies, and the public at large. In the case of large producers on public or private lands in areas where contact is likely to occur, a written and signed agreement outlining their rights and responsibilities under the terms of this protocol shall be made available to them. Each situation where mixing may occur may be somewhat unique and specifics of the agreement need to be tailored to the circumstances. Additionally, each region

is responsible for having local FWP contacts made available to land managing agencies and sheep and goat producers to resolve commingling issues should they occur. (2010a, 50)

More policy applicable to bighorn-domestic sheep-related negotiation is found in the Montana State Land Board's Administrative Rule 36.25.127, which covers domestic sheep grazing in bighorn habitat. This rule states:

(1) If a lessee/licensee has not grazed domestic sheep on the state tract at any time during the previous 10 years, and if the lessee/licensee requests a change to domestic sheep, then the department shall prepare a Montana Environmental Protection Act (MEPA) document at the appropriate level of review to examine the environmental impacts. In preparing the document, the department shall consult with the department of fish, wildlife and parks and the lessee/licensee and shall seek comments and interface as necessary with surrounding landowners and any interested public groups to design appropriate measures under the law.

(2) The department may allow grazing of domestic sheep on state lands within or adjacent to officially identified bighorn sheep ranges if bighorns are separated by a protective geographic buffer or if other applicable mitigation measures to minimize contact are negotiated and implemented. (Montana Secretary of State 2012)

***7.) If wandering bighorns got too close to domestic sheep, were they ever removed from the wild in or near this location?***

*Answer and Implementation*

In 2000, two yearling bighorn rams were shot on Mount Jumbo after being seen with about 90 domestic sheep used for weed control (MFWP 2010a; TUM 2001).

According to MPRD: "When wandering bighorns comingle with domestics, as occurred in June 2000 on the saddle of Mount Jumbo, MFWP must remove and kill the roaming bighorn(s) before they leave and possibly transmit lethal bacteria to other wild sheep" (2010, 119).

### Policy

According to MFWP: “Bighorn sheep coming in contact with domestic sheep and goats should be lethally removed immediately either by producers authorized to shoot the animal or by FWP employees. . .” (2010a, 49). The Montana bighorn plan makes frequent reference to fatally removing wandering bighorns. However, MFWP says: “Although Montana generally attempts to lethally remove bighorn sheep known to have had contact with domestic sheep and goats, only one of seven administrative regions has such a written protocol” (MFWP 2010a, 45).

### ***8.) Did coordination and/or tension exist between different levels (federal, state, local) of government management agencies regarding bighorn-domestic sheep interaction?***

#### Answer and Nature

The MFWP coordinated with UM and MPRD regarding domestic sheep used for weed control (TUM 2001; MPRD 2010). Though domestic sheep grazing did not occur on USFS land in 2010, Karen Stockman (a biological science technician for the Lolo National Forest) notes: “The Lolo NF current weed management plan includes grazing sheep and goat but we must consult with the FWP/FWS to ensure domestic-wild interactions are highly unlikely in an area if we choose to graze for weed control. So far we have not utilized this option” (2012). Montana Department of Fish, Wildlife, and Parks wildlife biologist Vickie Edwards noted that her agency coordinates with the USFS. Edwards also mentioned that some domestic sheep grazing near Mount Sentinel was prevented because of coordinated communication (2012). The MFWP regularly reviews the City of Missoula’s grazing rules (Edwards 2012).

Regarding bighorn-domestic sheep conflict, Missoula County turns to MFWP biologists for expert opinions. Much collaboration exists between MFWP and the



County. They have good communication (Canepa 2012). In general, agencies in the Missoula area have been fairly cooperative regarding the wild-domestic sheep disease issue. However, politics and cooperation trends significantly vary throughout the state and in different offices and regions (Edwards 2012).

### Policy

Montana's bighorn plan regularly mentions coordination between different levels of government (MFWP 2010a). Regarding disease risk mitigation, MFWP states: "Formal agreements should also be drafted with land management agencies regarding domestic sheep allotments, sheep used for weed programs, and habitat management programs and other activities that could impact bighorn sheep populations and herd health" (2010a, 49). The MFWP adds that it will "cooperate with public land management agencies and private individuals in the management of bighorn habitats" (2010a, 170).

### ***9.) Did you encounter funding difficulties regarding bighorn-domestic sheep interaction management?***

#### Answer and Nature

There have been some budgetary constraints on gathering baseline biological data on wildlife health at the state level, and health data can influence policy (Edwards 2012). However, funding difficulties did not seem to be a significant factor for separating bighorns from domestic sheep in the Bonner/West Riverside area. There were no wild-domestic sheep interaction funding issues regarding the City of Missoula's noxious weed program (Valliant 2012). Valliant explains that this was because:

. . . most of the significant changes [made to the grazing program in consideration of bighorns] were also necessary to make [the] program more effective. [For example,] having a herder on site 24-7 (90% of the program cost) ensures sheep

graze where we want them to, protects sheep from coyote/domestic dog attack, provides increased oversight ([so we] know when grazing goals have been met and it's time to move to another area) and also reduces chances of contact [with] bighorns. (2012)

### **Policy Efficacy Summary**

In the Bonner/West Riverside region, despite some problems, notable policy efficacy stands out. The area did not have clear buffers, allotment alteration, or trailing restrictions because it lacked domestic sheep grazing allotments. However, special supervision rules for sheepherders were in place (TUM 2001; MPRD 2010), and these rules probably prevented disease in some instances. At the time of the Bonner/West Riverside bighorn reintroduction, statewide policy existed that considered domestic sheep presence (MFWP 1986), but such policy was likely not applied to the Bonner area in a manner that seriously considered hobby animals. This reflects ineffective policy that may have contributed to disease.

Various forms of negotiation and education were carried out regarding Bonner wild-domestic sheep interaction (MFWP 2010a; TUM 2001; Missoula County 2005a, 2006, 2007) and probably helped delay the onset of disease. Bighorns too close to domestic sheep were removed from the wild (MFWP 2010a), and a die-off did not happen until 10 years later (WAFWA 2010c), so such lethal precautions may indicate effective interaction policy that prevents disease. The agency coordination and lack of tension and funding difficulties (TUM 2001; MPRD 2010; Stockman 2012; Edwards 2012; Valliant 2012) also contributed to effective policies that probably delayed a disease outbreak in the Bonner/West Riverside bighorn population.

## **Conclusion**

Bonner/West Riverside (which hosted a 2010 disease outbreak) marks the end of the results chapter, and analyzing that case study location reveals that, in general, by 2010, bighorn-domestic sheep interaction policy efficacy had improved. Nonetheless, after examining policies from different locations across the West, mixed efficacy trends have emerged. All locations were missing some key policies (buffers and trailing restrictions). The Tobin Range had some logical policies that were not effectively enforced. Aldrich Mountain had few known policies. The Highland/Pioneer Mountains and Tarryall/Kenosha Mountains largely lacked wild-domestic sheep interaction policies in general, and the Hays Canyon Range had some logical, clear policies that were not always implemented. A more in-depth examination of policy efficacy and the meaning of this chapter's case study analyses will occur in the next chapter.

## Chapter V: Discussion

### **Introduction**

An analysis of results for the six case study locations reveals various trends and themes regarding the efficacy of wild-domestic sheep separation policy. Biophysical geography and land ownership, bighorn population histories prior to outbreaks, nearby domestic sheep, epizootic events, and policy documents shed some light on what location/policy combinations were more *or* less effective at preventing wild-domestic sheep interaction leading to disease. However, examining the nine policy analysis criteria for each location revealed the most specific insights into policy efficacy.

### **Biophysical Geography & Land Ownership**

Of the cases examined, aside from sometimes increasing the difficulty of locating and monitoring domestic sheep and wandering bighorns, biophysical geography did not seem to play a significant role in determining policy efficacy. However, choosing case study locations to be representative was generally successful in representing landscapes pertinent to bighorn-domestic sheep interaction. Some representativeness regarding particular landscapes' policies was also somewhat achieved or at least potentially achieved, but to fully confirm such representation, many more case study analyses would need to be undertaken. Locations vary and are representative of much of the physical geography of bighorn habitats in the U.S., which feature their own forms of interaction policy.

The Tobin Range and Hays Canyon Range are arid, north-south high desert mountains with sagebrush and juniper. They are representative of California bighorn habitat and the more northerly desert bighorn ranges (BLM 2012; NDOW 2012b, d;

Google Earth 2012; BLM 2007a; Toweill and Geist 1999). They are also somewhat representative of Nevada's wild-domestic sheep interaction policies and how they are implemented or neglected in such areas. Bighorn die-offs in areas with domestic sheep have continued in Nevada when managers probably should have known better. This is evidenced by winter 2009-2010 die-offs in the Ruby Mountains and East Humboldt Range (WFWA 2010a) and a summer 2011 die-off in the Summer Mountains (DeLong 2011).

Collectively, the Highland/Pioneer Mountains and Tarryall/Kenosha Mountains are representative of many bighorn ranges in the Rockies with grassy slopes, fir and pine forests, alpine tundra, and high peaks reaching from up to 3,048 m (10,000 ft) to over 3,658 m (12,000 ft) (George et al. 1996; MFWP 2010a; Reese 1985). The Highland/Pioneer and Tarryall/Kenosha locations may also be representative of what interaction policy is like in areas where bighorns are native or were established prior to the domestic sheep disease threat becoming prominent.

The Bonner/West Riverside habitat (with meadows, talus slopes, and forested foothills) is representative of more populated, lower elevation portions of the interior Rockies where bighorns live near subdivisions in narrow river valleys or canyons (MFWP 2010a; Google Earth 2012). The author has visited similar bighorn habitat in Colorado's Big Thompson Canyon. As predicted, the presence of Bonner/West Riverside bighorns near people provided a unique opportunity to study the disease issue in the context of a populated area. Things like subdivision covenants and city weed control via domestic grazing were important factors there but not in the other studied locations

(MFWP 2010a). Bonner/West Riverside may be representative of other regions hosting bighorns near residential development.

Aldrich Mountain is representative of transitional habitat with varied terrain, elevations up to 2,118 m (6,950 ft), grassy slopes, and ponderosa pine (USFS 2010a). It is also in a region where high desert meets mid-latitude mountain forest (Google Earth 2012). It is uncertain just how representative Aldrich Mountain's policies may be of similar regions, partly because not many policy details were discovered for Aldrich Mountain.

High, steep river canyons were a bighorn habitat region not represented in this study. Because of Hells Canyon, this type of habitat hosted significant levels of bighorn disease deaths from 1990-2010 (Arthur et al. 1999; Cassirer et al. 1996). The extremely hot and cacti-clad southerly and Sonoran Desert ranges of desert bighorns were also not represented in this study. However, compared to other regions in the U.S., they did not experience significant disease outbreaks from 1990-2010 (Arthur et al. 1999; Jansen et al. 2007).

Habitat ownership/management designations varied for each location (Table 5.1). Before this study was carried out, assumptions were made regarding types and quantities of land ownership, which played a role in influencing some areas' policy efficacy. Going into this study, original suppositions were that desert and California bighorns would mainly be on BLM land. That proved correct. California and desert bighorns from case study locations lived in habitat that was more than 50 percent BLM land. However, Aldrich Mountain California bighorns lived on land with notably mixed ownership (BLM 1995).

Table 5.1. Bighorn habitat and land ownership allocations (approximate)

LOCATION & DIE-OFF DATES	U.S. FOREST SERVICE (USFS)	BUREAU OF LAND MANAGEMENT (BLM)	STATE	PRIVATE	SOURCES
Tobin Range (1991)	N/A	97%	N/A	3%	BLM 1995
Aldrich Mountain (1991)	24%	52%	9%	9%	BLM 1995
Highland/Pioneer Mountains (1994-1995)	32%	44%	4%	20%	BLM 1995
Tarryall/Kenosha Mountains (1997-2000)	Substantial	?	?	?	BLM 2011b
Hays Canyon Range (2007)	N/A	85%	N/A	15%	BLM 1995
Bonner/West Riverside (2010)	37%	N/A	5%	58%*	MFWP 2010a

\*Includes Plum Creek Timber holdings

Another supposition was that Rocky Mountain bighorns would mostly be on USFS land. This assumption was not wholly accurate. Land ownership for Rocky Mountain bighorns was more mixed than for the locations of the other subspecies. Highland/Pioneer bighorn habitat was mostly BLM land, Tarryall/Kenosha range was primarily USFS land, and Bonner/West Riverside bighorn use areas were mainly private land (BLM 1995; MFWP 2010a; BLM 2011b). The varied mosaics of land ownership probably made managing the disease issue more difficult and may have contributed to outbreaks and policy inefficacy.

All bighorn populations lived in habitat that included private lands. This was expected, but the amounts of private land were surprisingly significant. For example, including timber company land, the Lower Blackfoot Hunting District (containing the Bonner/West Riverside bighorns) was about 58 percent private land in 2010 (MFWP 2010a). Compared to the situation with grazing allotments on public land, wildlife and land management agencies have far less control over domestic sheep on private land, which increases the difficulty of forming and effectively implementing interaction policy. Private land domestic sheep proved to be a troublesome issue in the Tobin Range,

Highland/Pioneer Mountains, Tarryall/Kenosha Mountains, and Bonner/West Riverside (Ward et al. 1997; Tanner 2012a; Aune et al.1998; MFWP 2010a; Edwards et al. 2010).

### **Bighorn Population Histories Prior to Outbreaks**

Five of the six case study bighorn populations were transplant populations established by wildlife management agencies in areas where bighorns died off in the historic past. Population establishment dates range from 1967-1989. All transplant populations were augmented once after initial seed herd translocation (Table 5.2).

Examining bighorn population histories reveals some insights on disease patterns and policy trends.

**Table 5.2. Establishment of bighorn populations**

LOCATIONS & DIE-OFF DATES	DATES OF ESTABLISHMENT AND/OR AUGMENTATION	SUBSPECIES	SOURCE STOCK LOCATIONS	SOURCES
Tobin Range (1991)	1984, 1991	Desert	River Mtns., NV (1984), Black Mtns., NV (1991)	NDOW 2010; Ward et al. 1997
Aldrich Mountain (1991)	1978, 1981	California	Hart Mtn. National Antelope Refuge, OR	ODFW 2003
Highland/Pioneer Mountains (1994-1995)	1967, 1969	Rocky Mtn.	Sun River, MT	Aune et al. 1998; MFWP 2010a
Tarryall/Kenosha Mountains (1997-2000)	N/A (Native)	Rocky Mtn.	N/A	Toweill and Geist 1999
Hays Canyon Range (2007)	1989, 1995	California	Williams Lake, B.C. (1989), Jackson & Santa Rosa Mtns., NV (1995)	NDOW 2008a
Bonner/West Riverside (2010)	1987, 1990	Rocky Mtn.	Upper Rock Creek, MT (1987), Sun River, MT (1990)	MFWP 2010a

In the case of the Tobin Range, an augmentation of 18 bighorns was added to the existing population during the same year a disease outbreak struck (Ward et al. 1997). Ward et al. imply that such augmentations may contribute to disease outbreaks because augmentation bighorns may harbor disease antibodies that are infective to their new wild sheep companions (1997). However, the Tobin bighorns began to decline in August 1991



when domestic sheep were noticed trespassing on their habitat (Cummings and Stevenson 1995). The Tobin population was not augmented until October 1991 (Ward et al. 1997). That fact seems to rule out the possibility of augmentation bighorns being a primary disease catalyst in the Tobin Range, which implies an author or authors in Ward et al. 1997 may have been advocating policies that did not emphasize domestic sheep restrictions.

The Tarryall/Kenosha Mountains were the only case study location containing a native bighorn population (Toweill and Geist 1999). Compared to the other locations, the Tarryall/Kenosha Mountains had a notable lack of interaction policy (George 2012). Their bighorns' native status may have contributed to the lack of policy. For other locations, when new bighorn populations were established, the presence of domestics was considered beforehand, and correlating policy (some of it logical and at least somewhat effective) was formulated prior to reintroductions (BLM 1982; Foster 2012; Flores, Jr. 2012; MFWP 1986).

The Aldrich Mountain, Hays Canyon Range, and Highland/Pioneer bighorn populations demonstrated increasing trends not long before being hit by disease (USFS 1990a; ODFW 2003; NDOW 2006; MFWP 2010a). These population increases likely reduced efficacy of interaction policy and made separation more difficult. Larger numbers of bighorns may have also contributed to more rapid spread of disease. According to Aune et al., the increase of the Highland/Pioneer bighorn population could help explain why it suddenly suffered a pneumonia die-off in 1994 after coexisting with domestic sheep for about 20 years with no apparent disease problems (1998). The

importance of wild-domestic interaction policy may be less obvious to and more neglected by wildlife and land managers when bighorn populations are smaller.

### **Nearby Domestic Sheep**

The presence of nearby domestic sheep necessitates wild-domestic sheep interaction policies in the first place. If nearby domestic sheep are on private land, they can be more difficult to control, which can reduce policy efficacy. Additionally, the case of Aldrich Mountain illustrates some interesting temporal factors regarding transmission and the amount of time sheep are on the range. Furthermore, where the domestic sheep industry has strong political power, the effectiveness of interaction policies is diminished.

Going into this study, a major assumption was that most case study locations were in areas where domestic sheep grazed on public land as part of commercial operations. This assumption drove analysis criteria formulation. It explains why so many criteria relate to grazing allotments. However, the assumption proved incorrect. Five of the six case study locations were in areas that featured bighorn habitat near private land domestic sheep. In three locations, domestic sheep on private land were the only known domestic sheep in the area. Around the time of each outbreak, domestic sheep were on public land allotments in only two locations (Table 5.3).

The presence of domestic animals on private lands can limit and preclude wildlife management agencies' abilities and authority to manage livestock in efforts to protect wildlife. The private land factor likely contributed to disease outbreaks. Policy may be more effective or at least easier to implement when all domestic animals are on public lands. For example, a domestic sheep grazing allotment near Aldrich Mountain was altered after that area's epizootic, and no further disease outbreaks occurred there

(ODFW 2003). Private land domestic sheep are a prime example of a factor contributing to wildlife federalism complications. According to Anderson and Hill: “The history of wildlife management shows that a balance can be struck between individual, state, and national control, but this balance is currently missing” (1996).

Table 5.3. Domestic sheep near case study outbreak locations

LOCATIONS & DIE-OFF DATES	PRIVATE LAND ANIMALS	COMMERICAL PUBLIC LAND HERDS	WILD-DOMESTIC INTERACTION PRIOR TO DIE-OFF	SOURCES
Tobin Range (1991)	Yes <sup>1</sup>	No	Confirmed	Ward et al. 1997; Tanner 2012a
Aldrich Mountain (1991)	No	Yes	Possible	ODFW 2003; Foster 2012
Highland/Pioneer Mountains (1994-1995)	Yes	No	Confirmed <sup>2</sup>	Aune et al. 1998; MFWP 2010a
Tarryall/Kenosha Mountains (1997-2000)	Yes <sup>3</sup>	No	Confirmed	George et al. 2008; USFS 2007; George 2012
Hays Canyon Range (2007)	Yes	Yes	Possible	BLM 2007a; NDOW 2007; Surian 2012
Bonner/West Riverside (2010)	Yes	No <sup>4</sup>	Confirmed	MFWP 2010a; Stockman 2012; Edwards et al. 2010

1. These sheep also likely spent time on public land when they trespassed into bighorn range.

2. Bighorns coexisted with domestic sheep on overlapping range for nearly 20 years before the die-off. According to Aune et al.: "Several reports of bighorn rams breeding with and mingling with domestic sheep ewes were recorded prior to the pneumonia outbreak" (1998, 64).

3. Domestic sheep were nearby, and at least one domestic sheep spent time on public land bighorn range.

4. However, domestic sheep were used on nearby public lands for weed control.

The Aldrich Mountain situation is unique among the case studies because, based on findings for this project, the last time that confirmed and authorized domestic sheep grazing occurred on public land in the area was two years before the time of the die-off (Gibson 2012). That indicates temporal factors may have been influential. Initial infection and transmission to larger groups of wild sheep may have happened early with isolated bighorns that interacted with domestic sheep or used habitats on which they had been present before returning to their herds in 1991. Or, perhaps stray domestic sheep

from 1989 remained on Aldrich Mountain by 1991. With allotment users requesting permission to graze 600 domestic sheep in 1989 (USFS 1989a), stray animals seem likely. Grazing permittees may have also grazed domestic sheep without permission during 1991. Nonetheless, this is speculation. Aldrich bighorns may have contracted pneumonia from a non-domestic sheep source. Rules addressing cleanup of the range after domestic sheep are supposed to be off it could improve effectiveness of bighorn-domestic sheep interaction policies.

Nearby domestic sheep can be a greater obstacle to effective interaction policy in areas where the domestic sheep industry has significant political influence. Both Nevada and Montana stand out for these reasons (WAFWA 2010d; Person 2010; MFWP 2010a). As mentioned in Chapter II's controversy section, as recently as 2010, "[NDOW] caught hell from one of their new Commissioners" for killing a bighorn that came into contact with domestic sheep (WAFWA 2010d, 2). Reactions like this increase the difficulty of effectively implementing fatal bighorn removal policy. The MFWP makes special efforts to address the domestic sheep industry's preferences in its bighorn management plan (2010a), which reflects the strength of that industry in the state. The views and influence of domestic sheep producers (largely in the form of stubbornness and lack of cooperation) reduced the efficacy of interaction policies in Nevada's Tobin Range and Hays Canyon Range and in Montana's Highland/Pioneer Mountains (*Joe Saval Co. v. BLM and NDOW* 1991; Flores, Jr. 2012; Frisina 2012).

## **Outbreak Summaries**

Each case study location experienced an outbreak that either eliminated or greatly reduced its bighorn population. Variable recovery levels for the bighorn populations shed light on policy efficacy and disease trends.

The Tarryall/Kenosha Mountains population was native, and it had already experienced disease die-offs in the 1800s and 1950s (CDOW 2009). This could explain why, despite suffering suppressed lamb recruitment after their 1997-2000 pneumonia outbreak (George et al. 2008), the population managed to survive in higher numbers than other disease-stricken populations. The author speculates that perhaps some Tarryall/Kenosha bighorns have at least partial immunity to certain varieties of pneumonia bacteria because of their ancestors' exposure. Nonetheless, because of the population's strong historic association with disease, one would think wildlife managers might have taken better precautions with modern-day policies. The historic die-offs did not appear to have influenced Tarryall/Kenosha interaction policies by the 1990s.

Some case study populations were hit harder by disease than others (Table 5.4). For example, Aldrich Mountain bighorns largely recovered from their die-off (ODFW 2011). The post-outbreak alteration of domestic sheep grazing practices (ODFW 2003) may have contributed to their recovery. In contrast, disease completely wiped out Tobin Range bighorns in the early 1990s (Cummings and Stevenson 1995). There have also been no confirmed bighorn sightings in the Hays Canyon Range after that region experienced a 2007 die-off (Dobel 2012a). In discussions with biologists regarding the Hays Canyon Range, nothing was said about the area's domestic sheep allotments having been modified since the die-off. Lack of allotment modification policies after a die-off

can reduce the chances for straggler bighorns to survive or for new populations to become established.

Table 5.4. Outbreak summaries

LOCATIONS & DIE-OFF DATES	SUBSPECIES	OUTBREAK DISEASE	PRE-OUTBREAK POPULATION ESTIMATE	POST-OUTBREAK POPULATION ESTIMATE	CURRENT STATUS	SOURCES
Tobin Range (1991)	Desert	Pneumonia <sup>1</sup>	? <sup>2</sup>	1 (January 1992)	47 (2011) <sup>3</sup>	NDOW 2011, 2012a; Arthur et al. 1999; Cummings and Stevenson 1995; Ward et al. 1997; Tanner 2012a
Aldrich Mountain (1991)	California	Pneumonia	100 (1991)	32 (1991)	120 (2012)	ODFW 2003, 2012
Highland/Pioneer Mountains (1994-1995)	Rocky Mtn.	Pneumonia	400 (1993)	<50 (1998)	50-75 (2013)	Aune et al. 1998; MFWP 2010a; Boccadori 2013
Tarryall/Kenosha Mountains (1997-2000)	Rocky Mtn.	Pneumonia	375 (1996)	At least 72 bighorns directly killed by disease during outbreak	110 (2012)	CDOW 2012; George et al. 2008
Hays Canyon Range (2007)	California	Pneumonia	110 (2006-2007)	No confirmed bighorn sightings since the die-off		NDOW 2008a; WSF 2010; Dobel 2012a
Bonner/West Riverside (2010)	Rocky Mtn.	Pneumonia	160-180 (2010)	51-58 (2010)	67-76 (2011)	WAFWA 2010b; Crowser 2011

1. Anecdotal evidence strongly implicates pneumonia. However, "respiratory bacterial infection" is the only ailment cited in literature reviewed for this study.  
2. This population was established with 34 bighorns in 1984 and augmented with 18 more in 1991.  
3. A new bighorn population was established in the Tobin Range in 2003. Current numbers exist because of that effort.

Highland/Pioneer bighorns were severely reduced by disease, and lamb recruitment has remained suppressed (Aune et al. 1998; MFWP 2010a). The author speculates that this slow road to recovery may relate to continued contact with domestic sheep. However, suppressed lamb recruitment can occur after only a single epizootic (USFS 2006). As of 2010, domestic sheep hobby farms were still an issue in Highland/Pioneer bighorn range (MFWP 2010a). Additionally, according to meeting minutes of the Western Association of Fish and Wildlife Agencies' (WAFWA) Wild Sheep Working Group (WSWG), as of May 2009, the BLM Field Office in Butte, Montana (near Highland/Pioneer bighorns) had "completely ignored [WAFWA's

important wild-domestic sheep separation recommendations], and continued to permit/advocate/allow conflicting activities in close proximity to occupied [bighorn] habitats” (WAFWA 2009, 3). While this could indicate genuine neglect by the BLM and/or its prioritization of domestic sheep over the survival of bighorns, one must also remember that domestic sheep in the Highland/Pioneer Mountains area occur on private land where public agencies have limited control over livestock. According to MFWP, public land domestic sheep grazing allotments do not exist in the area (2010a).

Bonner/West Riverside bighorns suffered heavy losses, but the population has somewhat increased compared to initial post-outbreak numbers (WAFWA 2010c; Crowser 2011). This relates to the fact that the Montana Department of Fish, Wildlife, and Parks (MFWP) lethally culled numerous bighorns during the outbreak to prevent spreading of disease (Crowser 2011). In emergency situations, heavy culling may be an effective way to prevent further wild-domestic sheep interaction and disease spread.

### **Policy Documents**

Location-specific federal land management plans for only three case study areas addressed the wild-domestic sheep interaction issue (Table 5.5). The oldest federal plan addressing the disease problem was from 1982 (BLM 1982), and the most recent was from 2007 (BLM 2007a). Both of the investigated comprehensive state bighorn management plans containing policies that were applicable at the time of examined outbreaks heavily addressed the disease issue and contained reasonable and logical science-based policies (NDOW 2001; MFWP 2010a). However, these policies were not always effectively implemented or enforced prior to their correlating case study die-offs (Flores, Jr. 2012). What was sort of a proto-management plan (Nevada’s 1978 desert

bighorn biological bulletin) made a clear recommendation against wild-domestic sheep coexistence, but also reflected some outdated and erroneous knowledge regarding the disease threat of domestic sheep (NDFG 1978). For policy documents to be effective at wild-domestic sheep separation, they should actually be enforceable. To make bighorn protection components of documents more effective, more binding language should be inserted. For example, instead of mere guidelines, USFS plans should have more enforceable *standards* that are binding and address protecting bighorns from domestic sheep.

Table 5.5. Policy documents applicable at time of outbreaks

LOCATIONS & DIE-OFF DATES	WILD-DOMESTIC SHEEP INTERACTION ADDRESSED IN FEDERAL LAND MANAGEMENT PLAN	WILD-DOMESTIC SHEEP INTERACTION ADDRESSED IN STATE BIGHORN MANAGEMENT PLAN	DOCUMENTS/ SOURCES
Tobin Range (1991)	Yes	Yes <sup>1</sup>	BLM 1982; NDFG 1978
Aldrich Mountain (1991)	Yes	Yes	USFS 1990b; ODFW 1986
Highland/Pioneer Mountains (1994-1995)	No	N/A <sup>2</sup>	BLM 1979; USFS 1986, 1987
Tarryall/Kenosha Mountains (1997-2000)	No	N/A <sup>3</sup>	USFS 1984; George 2012
Hays Canyon Range (2007)	Yes	Yes	BLM 2007a; NDOW 2001
Bonner/West Riverside (2010)	No	Yes	USFS 1986b; MFWP 2010a

1. This was a biological bulletin intended to be a preparatory document for a more final management plan.

2. Montana did not have a comprehensive, statewide bighorn management plan until 2010.

3. Colorado did not have a comprehensive, statewide bighorn management plan until 2009.

## Policy Analysis Criteria

### 1. Clear Buffers

None of the examined case study locations had clearly defined buffer zones for separating wild and domestic sheep. Buffer zones were featured in the Desert Bighorn Council's (DBC) 1990 guidelines (DBC 1990) and the BLM's 1992 (BLM 1995a) and 1998 (BLM 1999) recommendations for managing domestic sheep in bighorn habitat.



Table 5.6. Policy analysis criteria

POLICY ANALYSIS CRITERIA	LOCATIONS AND DIE-OFF DATES					
	Tobin Range (1991)	Aldrich Mountain (1991)	Highland/ Pioneer Mountains (1994- 1995)	Tarryall/ Kenosha Mountains (1997- 2000)	Hays Canyon Range (2007)	Bonner/ West Riverside (2010)
<i>CLEAR BUFFERS</i>	No	No	No	No	No	No
<i>SPECIAL SUPERVISION RULES FOR SHEEPHERDERS</i>	No	No	N/A	N/A	No	Yes
<i>TRAILING RESTRICTIONS</i>	No	No	N/A	N/A	No	No
<i>CONSIDERATION OF DOMESTIC PRESENCE BEFORE REINTRODUCTION</i>	Yes	Yes	No	N/A <sup>1</sup>	Yes	Yes
<i>GRAZING ALLOTMENT ALTERATION EFFORTS</i>	Yes	Likely	N/A	N/A	Yes	N/A
<i>ADDITIONAL NEGOTIATION OR EDUCATION</i>	Yes	?	Yes	Yes <sup>2</sup>	Yes	Yes
<i>REMOVAL OF BIGHORNS NEAR DOMESTIC SHEEP</i>	No	?	Highly unlikely	No	Yes	Yes
<i>COORDINATION BETWEEN AGENCIES</i>	Yes	Likely	Yes	Yes	Yes	Yes
<i>TENSION BETWEEN AGENCIES</i>	No	Possibly	Possibly	Unlikely	Yes	No <sup>3</sup>
<i>FUNDING DIFFICULTIES</i>	No	?	No	N/A	No	No
<i>SOURCES</i>	BLM 1982; DBC Technical Staff 1990; Jeffress 2012a; Arthur et al. 1999; Tanner 2012a, b	Foster 2012; ODFW 1986; USFS 1988, 1989a, b	Frisina 2012; MFWP 2010a; Aune et al. 1998	George 2012; USFS 2007; Toweill and Geist 1999; Arthur et al. 1999	Flores, Jr. 2012; Epps et al. 2003; BLM 2007a; NDOW 2001; Soletti 2012	Edwards 2012; TUM 2001; MPRD 2010; Stockman 2012; MFWP 1986; MFWP 2010a; Valliant 2012

1. These bighorns were native, so no reintroduction was necessary.

2. Education occurred because of the outbreak, but it happened afterward.

3. Compared to other locations, research did not reveal significant agency tension in this area.

The 1990 DBC guidelines were applicable to the Tobin Range, and the 1998 BLM recommendations were applicable to the Hays Canyon Range. Montana's bighorn management plan (MFWP 2010a) also specifically mentions buffer guidelines, and it was applicable to Bonner/West Riverside.

As Schommer emphasized, buffers are not always effective because of the sometimes unpredictable and wide-ranging movement patterns of wild and domestic sheep and the rugged terrain both species often inhabit (USFS 2010b). Also, though biologists have since learned that buffer zones of about 13.5 km (roughly 9 mi) wide are inadequate, that has not stopped the BLM from using the 13.5 km figure in its resource management planning processes (Tanner 2012a; BLM 1999). The ODFW, MFWP, and the U.S. Fish and Wildlife Service (USFWS) have also used the 9-mile buffer value (Foster 2012; MFWP 2010a; USFWS 2000). Regardless of their inefficacy, the lack of attempts at establishing buffers may have been a key policy weakness that contributed to disease striking all case study locations.

## 2. Special Supervision Rules for Shepherders

Five of six examined locations lacked special supervision rules for shepherders. This lack of supervision rules indicates weak policy that may have contributed to wild-domestic sheep disease transmission. Bonner/West Riverside was the only case study area that had location-specific supervision rules for shepherders. These supervision rules applied to the City of Missoula grazing domestic sheep on open space lands to control invasive plants (TUM 2001). Missoula does not graze domestic sheep in January, which was when the Bonner die-off occurred (Stockman 2012; WAFWA 2010c). Thus, the weed control supervision rules in the Bonner/West Riverside region appear to be an

example of effective interaction policy that successfully separates wild and domestic sheep.

### 3. Trailing Restrictions

None of the examined case study locations had trailing restrictions on domestic sheep. This lack of trailing restrictions indicates policy inefficacy that may have contributed to disease outbreaks. However, trailing restrictions existed in print as broad guidelines (DBC Technical Staff 1990; BLM 1999) that could have been applied to the Tobin Range and Hays Canyon Range. In the case of the Hays Canyon Range, the BLM had reasonable, logical policy (BLM 1999, 2007a, b) that they neglected to implement or enforce (Flores, Jr. 2012).

### 4. Consideration of Domestic Presence Before Reintroduction

The concept of prohibiting bighorn reintroduction to a site if it currently hosted domestic sheep was considered or part of policy in all but one case study location that hosted transplanted populations. This consideration may have delayed disease outbreaks and can demonstrate effective interaction policy. However, to prevent disease outbreaks, existing domestic sheep presence should be considered and resolved more thoroughly and effectively than what transpired in this project's case study locations.

### 5. Grazing Allotment Alteration Efforts

Grazing allotment alteration efforts were successfully implemented in at least two locations before die-offs: the Tobin Range and the Hays Canyon Range (Tanner 2012a; Flores, Jr. 2012; BLM 2007a). Allotment alteration may have delayed the onset of disease from domestic sheep. However, in the Hays Canyon Range, a domestic sheep allotment was preserved near bighorns (BLM 2007a). If grazing allotment alteration will

contribute to effective policy, it should be done thoroughly and consistently throughout a bighorn population's range.

#### 6. Additional Negotiation or Education

General negotiation and education aside from that related to altering grazing allotments happened in at least five of the six case study locations. Education and negotiation can be ineffective if done too late, as was the case in the Tarryall/Kenosha Mountains where agency representatives talked to a domestic sheep owner after the region's bighorn disease outbreak (George 2012). They can also be ineffective if locals are recalcitrant or skeptical of science. However, education and negotiation can lead to effective policy when multiple parties recognize the same risks and coordinate. This was the case in the Bonner/West Riverside area regarding the City of Missoula's grazing of domestic sheep. Effective negotiation and education involves all parties getting on the same page and participants' acceptance of wild-domestic sheep disease science.

#### 7. Removal of Bighorns Near Domestic Sheep

Cases of wildlife managers removing bighorns that got too close to domestic sheep were discovered for two case study locations: the Hays Canyon Range and Bonner/West Riverside (Epps et al. 2003; MFWP 2010a). A bighorn interacting with domestic sheep on a mountain range adjacent to the Hays Canyon Range was removed seven years before the area's 2007 die-off (Western Hunter 2000). This indicates the removal may have delayed a disease outbreak and served as an example of effective separation policy implementation.

In the Bonner/West Riverside area, two bighorns near domestic sheep were removed 10 years before that region's 2010 disease outbreak, which also implies

effective policy delaying disease. However, the removed bighorns were near domestic sheep grazed by the City of Missoula, which has a history of cooperation with MFWP (MFWP 2010a). The 2010 Bonner/West Riverside die-off likely resulted from subdivision animals. Thus, the bighorn removal policy is most effective if done consistently for *all* at-risk wandering wild sheep.

Nonetheless, Curtis M. Mack (Bighorn Sheep Recovery Project Leader for the Nez Perce tribe) criticizes the efficacy of the removal policy and indicates that sometimes “the need to remove bighorn sheep because of interactions with domestic sheep or goats should be viewed as a management failure triggering implementation of more effective separation strategies to prevent contact and preclude the need for further removal of wild sheep” (2008, 215).

#### 8. Coordination/Tension Between Agencies

Bighorn-domestic sheep disease-related coordination between different levels of government agencies existed for at least five of the case study locations. Coordination can help delay or prevent disease. However, coordination by itself is not necessarily an effective policy quality, considering five examined locations’ agencies coordinated *and* failed to prevent bighorn die-offs. To be an effective component of policy, coordination must be consistently implemented with parties who care about taking action in a timely manner.

Tension between different agencies regarding the disease issue was indicated for two locations (Aldrich Mountain and Highland/Pioneer Mountains), unlikely in one location (Tarryall/Kenosha Mountains), not detected for one location (Bonner/West Riverside), and definite for at least one location (Hays Canyon Range). Tension and

disagreement can reduce policy efficacy by delaying or preventing policy formulation or implementation. In all locations where tension seemed to play a role in wild-domestic sheep interaction management, it appeared to make implementation of policy less effective.

### 9. Funding Difficulties

Regarding wild-domestic sheep interaction practices, funding difficulties were not discovered to be in existence or significant for any of the case study locations. This project's results reveal that funding difficulties probably did not contribute to the case study disease outbreaks. While funding in the case study locations might have contributed to more personnel addressing wild-domestic sheep interaction, field enforcement of regulations, separation barriers, expanded education, and special monitoring programs, special funding for these things appeared to not be a concern of wildlife managers around the time of each outbreak. In improving policy efficacy, factors like coordination, will to actually implement enforcement, and education are probably more important than funding. When it comes to protecting bighorns from domestic sheep, biologist Mike Dobel emphasized that politics can be more influential than money (2012a).

### **General Temporal Trends**

One temporal trend revealed by this study involves key wild-domestic sheep interaction policies being released very close to the time of a region's die-off. For example, the Tobin Range's 1991 desert bighorn die-off happened a year after the DBC released special guidelines (DBC 1990) for managing domestic sheep in desert bighorn habitat. Additionally, important wild-domestic sheep policy was described in a Malheur

National Forest plan (USFS 1990b) released a year before the Aldrich Mountain die-off. This is an interesting coincidence, but it is worth noting that the domestic sheep implicated in that outbreak were actually on the nearby Ochoco National Forest. Furthermore, Montana's first comprehensive bighorn management plan (MFWP 2010a) was released in January 2010, which was also when the Bonner/West Riverside outbreak happened. Having die-offs happen in such close temporal proximity to policy publication indicates a lag time between policy publication and implementation. It also underscores the urgency and necessity of better bighorn-domestic sheep separation policies. Such policies do not address vague, distant threats. They deal with a current problem that regularly occurs and must be confronted.

Based on the research performed for this project, the wild-domestic sheep disease issue gained prominence from 1990-2010 in policy documents, politics, and in the minds of agency biologists. For example, policy information preceding the 1991 Tobin Range and Aldrich Mountain die-offs was more difficult to find than for all other die-offs. However, policy information applicable to the 2010 die-off was the most abundant and easiest to discover. As time passed, more wild-domestic sheep interaction policies were formulated and documented. For instance, within the time range of 1990-2010, Nevada and Montana significantly strengthened and expanded their wild-domestic sheep interaction policies and covered them in their management plans (NDOW 2001; MFWP 2010a). The other case study states also now have reasonable management plans with logical disease policy in print (ODFW 2003; CDOW 2009).

While improved policies may not always be more effective on the ground, policy improvement on paper has occurred. History indicates that policies will keep improving,

despite obstacles. Nonetheless, considering how frequently bighorn die-offs continue to occur, the improvement of policy implementation is crucial but more uncertain.



## Chapter VI: Conclusion

### **Introduction**

This study's results illustrate the importance of custodial wildlife management when it comes to the tough task of preventing bighorn-domestic sheep interaction through effective policy. Its findings also verify the conclusions of other wild-domestic sheep interaction policy researchers. Additionally, this study serves as a valuable information resource for natural resource managers who are often charged with both policy formulation/improvement and implementation.

This project's shortcomings include a limited geographic scope, a dearth of information available for the Aldrich Mountain case study, and an absence of field research. Furthermore, this analysis was bighorn-centric and government agency-centric with little representation of the views of the domestic sheep industry. Moreover, this study focuses almost exclusively on domestic sheep, though domestic goats present a similar disease threat to bighorns. Although all these shortcomings could be addressed with further research, additional research could also be done by geographers adapting the methodology of this thesis to other contentious wildlife-livestock interaction policy issues.

Bighorn management in general, and bighorn-domestic sheep management in particular, involve many stakeholders and the science/policy interface. The wild-domestic sheep issue has gained much attention in recent years and is poised to continue its high profile role in the drama of the American West's natural resource management controversies. Bighorns need human protection and help for their effective conservation,

and complete separation of wild and domestic sheep is one of the best ways to conserve bighorns. Nonetheless, that solution is not always easily implemented in reality.

### **Findings' Relationship with Management Approaches**

Research for this thesis repeatedly verified that bighorns and domestic sheep are not compatible on the same ranges. Other researchers arrived at this conclusion in similar policy/location analysis literature discussed in Chapter II (Monello, Murray, and Cassirer 2001; Clifford et al. 2009; Cahn et al. 2011). This study's findings tie into, verify, and could improve wildlife management and wild-domestic sheep management approaches. The case studies in this project illustrate that bighorn-domestic sheep interaction policies (both custodial and manipulative) can sometimes be successful with diligence, but success is unpredictable and location-dependent. This determination verifies Schommer's views discussed in Chapter II. Schommer notes: "Each allotment includes grazing practices specific to the allotment and permittee and each allotment carries its own set of unique circumstances that need to be evaluated. What works in one location may not work in another" (USFS 2010b, 1).

Results of this study also underscore the need for better preventative, custodial management of bighorns. Manipulative management can be expensive and time-consuming, and it may not amount to much if insufficient custodial management results in the elimination of a bighorn herd because of a disease outbreak. Moreover, the findings of this research indicate that the domestic sheep disease threat should be a staple of any bighorn management guidelines. Though lacking in some older publications (McQuivey 1978; Wishart 1978), the bighorn-domestic sheep disease issue has become increasingly prominent in the bighorn management literature.

As repeatedly emphasized in Chapters I and II, this study can serve as a valuable information resource that could improve and mature the field of bighorn management. This thesis will be an important tool for biologists, land managers, and policy specialists unfamiliar with the disease issue (e.g., those who experienced geographic transfers or promotions that necessitate awareness of the intricacies of bighorn-domestic sheep interaction management). In their response to a survey questionnaire presented to bighorn managers at the 2<sup>nd</sup> North American Wild Sheep Conference, Cummings and Stevenson emphasized that Nevada regularly receives federal agency personnel from Washington who are not knowledgeable about important bighorn-related issues (Arthur et al. 1999).

### **Shortcomings and Need for Additional Research**

This project only analyzes six case study locations of an estimated 66 known die-off events that occurred from 1990-2010 (Ryder et al. 1992; Miller et al. 1995; Cassirer et al. 1996; Torres, Bleich, and Wehausen 1996; Ward et al. 1997; Aune et al. 1998; Cummings and Stevenson 1998; Arthur et al. 1999; Coggins et al. 2000; Merwin and Brundige 2000; ODFW 2003; Jansen et al. 2007; Rominger and Goldstein 2007; USFS 2007; Buchanan 2008; Byron 2008; George et al. 2008; Malmberg, Nordeen, and Butterfield 2008; NDOW 2008a; Olson et al. 2008; Cassaigne, Medellín, and Guasco 2010; MFWP 2010a; WAFWA 2010a; WAFWA 2010c; Wolfe et al. 2010). It is important to note that due to incomplete information, this estimate is probably low. As such, this study might have yielded more conclusive results if it analyzed more locations, but it is felt that the results are representative of those that would be obtained from a larger study and that they can adequately inform wildlife management policies and managers. Representative, important bighorn habitats were analyzed, but the case study

locations did not include hot desert, steep river canyons, or Great Basin rimrock.

Attempting to represent these other habitat types could be part of additional case studies or an expanded study.

Furthermore, for years, Hells Canyon (carved by the Snake River and located where Oregon, Idaho, and Washington meet) has been a major focal point of bighorn-domestic sheep disease controversy, and this study only briefly touches on it. Studies focusing on subpopulations of bighorns within Hells Canyon and analyzing related domestic sheep allotments and related management policies and litigation could produce substantive research results that reinforce and expand on the findings of this project. The Payette National Forest borders Hells Canyon, and the flurry of bighorn-domestic sheep policy activity in the Forest was also only briefly addressed in this study and could form the basis for additional policy analysis.

Information concerning several of the case study locations was especially limited or non-existent. For example, not many details were discovered for Aldrich Mountain, particularly regarding possible conflict between the Oregon Department of Fish and Wildlife and the U.S. Forest Service. This project could benefit from further study of the Aldrich Mountain die-off. Additionally, along with secondary research, only phone and e-mail interviews were conducted. On-the-ground research focusing on field office records (e.g., documents concerning range conditions, grazing allotments, domestic sheep and/or bighorn dynamics, etc.) and in-person interviews could yield information with greater quantity and quality.

An especially notable shortcoming of this project is that all individuals interviewed were either wildlife managers or public land managers. The literature that

was examined was also skewed toward that originating from wildlife and land management agencies. This thesis is admittedly bighorn-centric, but further fleshing out the views of the domestic sheep industry and sheep operators would provide more balanced and interesting results. The implementation of many interaction policies ultimately depends on the discretion and cooperation of sheep owners and herders. A sequel project using the same general approach as this thesis (case study profiles with policy analysis) *but* focusing on domestic sheep operators could generate incisive and useful complementary research.

Another shortcoming of this study was that it only focused on domestic sheep when wild-domestic sheep interaction policies also apply to domestic goats, which pose a similar disease threat. In addition to being raised and used for similar purposes as domestic sheep, domestic goats are sometimes used by recreationists as pack animals in high mountain bighorn habitat. That factor could add a new dimension to bighorn-livestock interaction policy analysis. In general, domestic goat-bighorn interaction policies and situations related to disease transmission could provide rich material for additional research, especially because the goat industry has been on the rise in the U.S. According to Professor Solaiman: “In the United States, meat goat production has been gaining popularity in recent years particularly because of a growing population of ethnic and faith-based groups who consume goat meat” (2007, 2).

The methodology of this project—with its regional comparisons, cultural biogeography, and nature conservation themes—could serve as a template for additional geographic studies of controversial natural resources policy issues. This project looks at pastoralism’s detrimental impact on wildlife, which is something geographers have not

significantly studied and may wish to investigate in more detail. For example, bison-cattle disease interaction management is another topical, dynamic subject that could be geographically analyzed in the same manner as the bighorn-domestic sheep disease issue.

### **Takeaway Message**

Lisa K. Harris and William W. Shaw (researchers at The University of Arizona) state: “Mountain sheep management takes place in the arenas of biology, politics, interagency conflicts and cooperation, public opinion, and the public policy development process” (1993, 16). Bighorn-domestic sheep interaction management involves controversy associated with economic and cultural tensions, science denial, litigation, legislative maneuvering, and research and advocacy—all of these are poised to continue. The bighorn-domestic sheep disease issue is destined to gain prominence and media attention in future years as bighorn numbers expand, new findings come to light, and more people become aware of the topic’s importance.

If bighorns and domestic sheep are to coexist in the same areas without disease outbreaks devastating wild sheep, one size-fits-all interaction policies covering the entire American West will not be effective. To quote Colorado Division of Wildlife veterinarian Mark Miller: “I believe segregating bighorn and domestic sheep on native ranges remains the single most effective management tool for preventing pneumonia epidemics in free-ranging bighorn sheep” (USFS 2001, 4). From a strictly ecological context, not allowing domestic sheep and bighorns to share the same ranges at all is the least risky and most effective way to prevent bighorn die-offs caused by domestic sheep.

However, bighorn and domestic sheep stakeholders live in a world where wild-domestic sheep interaction also exists in political and economic contexts. Complete

removal of domestic sheep in bighorn ranges will not always be possible or desirable. Bighorn-domestic sheep interaction management policies should involve compromise and prioritization if they are to be successful. This could mean fewer or no bighorns or domestic sheep in certain areas—and fewer futile attempts to maintain coexistence.

Wildlife veterinarian Deana L. Clifford et al. aptly share some of these same conclusions in their assessment of wild-domestic sheep disease risk in the Sierra:

To eliminate all risk of contact and potential disease transmission, domestic sheep cannot be grazed on allotments that overlap with areas utilized by Sierra Nevada bighorn sheep. Where wildlife and domestic animal populations share limited habitat, and there is documented evidence of a substantial disease threat and extinction risk, stakeholders must recognize that the only way to eliminate contact and risk of disease transmission is to give priority to one species or the other. If conservation is the priority, difficult decisions will need to be made to balance trade-offs between economic livelihoods and species conservation. (2009, 2559)

The case of bighorns in the Sierra (Reiterman 2005; USFWS 2007; CDFG 2009) illustrates how the Endangered Species Act (ESA) could be used more often to motivate more effective wild-domestic sheep separation policies. The ESA is powerful, and the act itself (or merely the fear of ESA designation) can trigger increased policy efficacy and more innovative management approaches. Though not all bighorns are endangered, the ESA allows for the listing of special subpopulations: subspecies, distinct population segments (DPSs), and evolutionarily significant units (ESUs) (Nie 2012b). Getting DPS or ESU designation for particularly vulnerable bighorn populations near domestic sheep could result in rapid development of effective policies and maybe even complete removal of domestic sheep.

While complete removal of domestic sheep is a clear way to reduce bighorn health risks, issues of economics and social justice should not be dismissed. Federal agencies should make domestic sheep removal agreeable to livestock producers through

reasonable, fair means. Aside from the obvious incentive of direct payment, agencies could implement efforts to perform land swaps with ranchers in regions with checkerboard private/government ownership patterns. Such swaps might compensate sheep ranchers for lost range and better consolidate portions of bighorn habitat in the public domain.

Agencies could also take advantage of the fact that bighorns may often have more economic value in particular areas than domestic sheep. Bighorns are popular enough to have become the state mammal in Nevada and Colorado, and bighorn hunting permits have been auctioned for hundreds of thousands of dollars (BLM 1995b; ODFW 2003). Federal agencies could promote bighorns' economic value in their efforts to remove domestic sheep. They could also help domestic sheep ranchers transition from grazing to forms of economic activity that involve bighorns. For example, some domestic sheep operators could become outfitter-guides who help hunters and wildlife viewers find bighorns in the backcountry. Though the feasibility of this idea is highly variable based on location, in some instances, it might compensate for producers losing allotments.

Wild sheep biologist Wayne E. Heimer ends his 2002 analysis of the bighorn-domestic sheep disease issue by remarking:

My recommendation for wildlife biologists would be to leave the bacterial adventures and vaccine development to specialists in those fields, and to concentrate on doing the best we can to humanely separate bighorns from domestics. It's not sexy, and it's not new; but it will probably do more for bighorns than the excursions into DNA, diseases, and parasites that have occupied us for the last 50 years. (2002, 164)

Bighorn biologists Raul Valdez and Paul R. Krausman provide a reminder of why bighorn conservation matters:



Mountain sheep, like all other native fauna and flora, are a part of the structure and heritage of North America. Despite all of the efforts exerted toward their conservation, wild sheep face a precarious future. They are an ecologically fragile species, adapted to limited habitats that are increasingly fragmented. . . . According mountain sheep their rightful share of North America and allowing them to inhabit the wilderness regions they require is a responsibility all Americans must shoulder. It is our moral and ethical obligation never to relent in the struggle to ensure their survival. (1999, 22)

In autumn 1939, Oregon State College graduate Don Moore undertook an assignment for the U.S Biological Survey to seek Oregon's last bighorns in Hells Canyon. Moore failed to find bighorns or even their tracks. However, he heard at least one story from a local who connected bighorn disappearance with domestic sheep arrival (Hoffman 2007). Though focused on northeast Oregon, in Moore's report on his investigation, he asked a question that could be applied to much of the American West well into the twenty-first century: "Are mountain sheep . . . of more value to the people of the nation as a whole than is the grazing industry in this area" (Hoffman 2007)?



Figure 5.1. Rocky Mountain bighorn ram surveys his wilderness domain in northwest Montana. Photograph by National Park Service (NPS 2012a).

*Appendix A. Epizootics and mortalities reported in bighorn sheep in the  
USA and Canada, 1881-2005 - Adapted from Cassaigne, Medellín, and Guasco 2010*

DATE	LOCATION	INITIAL POPULATION SIZE	MORTALITY	ASSOCIATED DISEASE/POSSIBLE CAUSE	EPIZOOTIC ORIGIN	REFERENCE
1881-1885	Wyoming	Unknown	Unknown	Scabies	Unknown	Lange 1980
1880-1890	Montana	Unknown	Unknown	Scabies	Unknown	Lange 1980
1870-1880	Idaho	Unknown	Unknown	Scabies	Unknown	Goodson 1982
1870-1879	California	Unknown	Unknown	Scabies	Unknown	Lange 1980
1900-1920	Rock Creek, Montana	Unknown	Unknown	Not determined	Unknown	Goodson 1982
1917-1930	Rocky Mountain National Park, Colorado	Unknown	Unknown	Pneumonia	Unknown	Goodson 1982
1916-1922	Utah	Unknown	Unknown	Scabies	Unknown	Goodson 1982
1925	Sun River, Montana	Unknown	70%	Not determined	Unknown	Goodson 1982
1931	Colorado	Unknown	Unknown	Scabies	Unknown	Lange 1980
1936	Oregon	Unknown	Unknown	Scabies	Unknown	Lange 1980
1939	Kootenay National Park, British Columbia	Unknown	Unknown	Pneumonia	Unknown	Goodson 1982
1942-1950	Thompson Falls, Montana	50	100%	Contact with domestic sheep	New pathogen	Goodson 1982
1950	Dinosaur National Monument, Colorado	Unknown	100%	Not determined	Unknown	Goodson 1982
1965-1970	Upper Rock Creek, Montana	150	100%	Pneumonia/contact with domestic sheep	New pathogen	Goodson 1982
1965	Bull River, British Columbia	250	97%	Pneumonia/contact with domestic sheep	New pathogen	Goodson 1983
1955-1970	Big Hatchet, New Mexico	125-150	84%	Drought and other factors	Stress factors	Watts 1979
1971	Black Gap Wildlife Management Area, Texas	20	90%	Pneumonia/stress when being released	Stress factors	Kilpatric 1982
1976-1978	San Andreas National Wildlife Refuge, New Mexico	200	67%	Scabies/changes in weather	Stress factors	Sandoval 1980
1980-1981	Black Mountains, California and Nevada	511	38%	Scabies/drought, high population density	Stress factors	Welsh and Bunch 1982
1980-1981	Waterton Canyon, Colorado	77	77%	Pneumonia/human activities	Stress factors	Bailey 1986
1981-1982	Macquire Creek, British Columbia	50	52%	Pneumonia/contact with domestic sheep	New pathogen	Goodson 1982
1980	Lava Beds National Monument, California	42	76%	Pneumonia/capture stress	Stress factors	Blaisdell 1982
1981	Mormon Mountains, Nevada	600	50%	Pneumonia/contact with domestic sheep	New pathogen	Jessup 1981
1979-1981	Methow Game Range, Washington	14	93%	Pneumonia/contact with domestic sheep	New pathogen	Foreyt and Jessup 1982
1982	Wigwam, British Columbia	300	50%	Pneumonia/contact with domestic sheep	New pathogen	Goodson 1982

1988	Warner Mountains, California	65	100%	Pneumonia/contact with domestic sheep	New pathogen	Weaver 1989
1981	Latir Parks [ <i>sic</i> ], New Mexico	36	100%	Pneumonia/contact with domestic sheep	New pathogen	Sandoval 1988
1985	Sheep River Wildlife Sanctuary, Alberta	250	54%	Apparent pneumonia	Stress factors	Festa-Bianchet 1988
1986	Lostine, Wallowa Mountains, Oregon	97	70%	Pneumonia/contact with domestic sheep	New pathogen	Coggins and Matthews 1992
1988	Southeast Washington	80	62%	Scabies/contact with transplanted Rocky Mountain bighorns	New pathogen	Foreyt et al. 1990
1989	Aravaipa Canyon, Arizona	195	59%	Blue tongue-epizootic hemorrhagic disease unknown/drought/cattle presence	Mixed origins	Mouton et al. 1991
1990-1991	Whiskey Mountains, Wyoming	600-900	30-40%	Pneumonia/cold temperatures	Stress factors	Ryder et al. 1992
1992-1993	East Range, Nevada	Unknown	Unknown	Not determined	Unknown	Martin et al. 1996
1992-1993	Desatoya Range, Nevada	Unknown	Unknown	Pneumonia	unknown	Martin et al. 1996
1995	Hells Canyon, Washington and Oregon	700	50-75%	Pneumonia/presence of cattle, goats, domestic sheep	Mixed origins	Cassirer et al. 1996
1997-2000	Kenosha and Tarryall Mountains, Colorado	250	50%	Contact with domestic sheep	New pathogen	George et al. 2008
2005	Custer State Park, South Dakota	200	75%	Contact with domestic sheep	New pathogen	Freeman 2006

*Appendix B. Bighorn Die-offs Believed to Have Resulted from  
Domestic Sheep, 1900-1995 – Adapted from USFS 2001*

DATE	LOCATION	RESULT	DIE-OFF CAUSE	SOURCE
1900-1920	Rock Creek, Montana	All but 8 died	Unknown	Goodson 1982*
1910-1935	Sun River, Montana	>70 died	Unknown	Goodson 1982*
1917-1930	Rocky Mountain National Park, Colorado	All died	Pneumonia	Packard 1939a, b in Goodson 1982*
1939	Kootenay National Park, British Columbia	No specific data provided	Pneumonia	Goodson 1982*
1940-1960	Thompson Falls, Montana	All died	Unknown	Goodson 1982*
1950	Dinosaur National Monument, Colorado	All died	Unknown	Barmore 1962 in Goodson 1982*
1965	Bull River, British Columbia	96% died	Pneumonia	Brandy 1968 in Goodson 1982*
1965-1970s	Upper Rock Creek, Montana	All died	Unknown	Goodson 1982*
1970s	Utah State University **	All died	Pneumonia	Spillett in Goodson 1982*
1970s	University of British Columbia **	All died	Pneumonia	Herbert in Goodson 1982*
1970s	Colorado State University **	All died	Pneumonia	Hibler in Goodson 1982*
1978-1982	Latir Parks [ <i>sic</i> ], New Mexico	All died	Pneumonia	Sandoval 1988*
1979-1981	Methow Game Range, Washington ***	13 of 14 died	Pneumonia	Foreyt and Jessup 1982*
1980	Lava Beds National Monument, California ***	All died	Pneumonia	Blaisdell 1982* and Hunt 1980
1980	Mormon Mountains, Nevada	50% died	Pneumonia	Jessup 1981*
1981-1982	MacQuire Creek, British Columbia	No specific data provided	Pneumonia	Davidson in Goodson 1982*
1986	Lostine, Oregon	70% died	Pneumonia	Coggins 1988
1988	Warner Mountains, California	All died	Pneumonia	Weaver 1988*
1988	Utah State University **	4 of 5 died	Pneumonia	T.D. Bunch (Utah State University, Personal Communication)
1988	Sheep River, Alberta **	2 of 2 died	Pneumonia	Onderka 1988
1989	Washington State University **	6 of 6 died	Pneumonia	Foreyt 1989

1990	Washington State University **	2 of 2 died	Pneumonia	Foreyt 1990
1991	Utah State University **	5 of 5 died	Pneumonia	Callan 1991
1991	Washington State University **	2 of 2 died	Pneumonia	Foreyt 1991
1992	Washington State University **	5 of 6 died	Pneumonia	Foreyt 1992
1992-1993	East Range, Nevada	85 died	Unknown	Hunter 1993 (Idaho Department of Fish and Game, Personal Communication)
1992-1993	Desatoya Range, Nevada	No specific data provided	Pneumonia	Tanner 1993 (Nevada Division of Wildlife, Personal Communication)
1993	Caine Veterinary Center, University of Idaho	2 of 4 died	Pneumonia	Hunter 1993 (Idaho Department of Fish and Game, Personal Communication)
1994	Tollgate	1 ram died	Pneumonia	Hunter 1996 (Personal Communication)
1995	Hells Canyon	1 ram died	Pneumonia	Hunter 1995

\* From Desert Bighorn Council 1990

\*\* University Controlled Conditions

\*\*\* Large Pen or paddock

*Appendix C. Winter 2009-2010 Bighorn Pneumonia Die-Offs in the Western U.S.  
(as of June 21, 2010) – Adapted from WAFWA 2010a*

DIE-OFF LOCATION	POPULATION ESTIMATE PRIOR TO DIE-OFF	# OF BIGHORNS CULLED	# OF KNOWN ADDITIONAL MORTALITIES	BIGHORN MORTALITY ESTIMATE (#, %)	KNOWN, LIKELY, OR POSSIBLE ASSOCIATION WITH DOMESTIC SHEEP OR GOATS PRIOR TO DIE-OFF
East Fork Bitterroot, Montana	200-220	80	N/A	≈ 100, 50%	Known
Bonner/West Riverside, Montana	160-180	99	4	≈ 110, 68%	Known
Lower Rock Creek, Montana	200	18	N/A	87, 43%	Possible
Upper Rock Creek, Montana	≈ 340	39	N/A	≈ 200, 60%	Possible
East Humboldt Range, Nevada	160-180	1	113	140, 80%	Likely
Ruby Mountains, Nevada	160	1	36	100, 65%	Possible
Yakima River Canyon, Washington	280	69	42	99, 33%	Possible
North Slope of the Uinta Mountains, Utah	50-70	51	0	50, 95%	Unknown
Gros Ventre River, Wyoming	50-60	2	0	2, 5%	Unknown
Totals	1,600-1,680	360	195	888 dead bighorns	

*Appendix D. Montana Bighorn Die-Offs, 1984-2008 – Adapted from MFWP 2010a*

DATE	LOCATION	POPULATION ESTIMATE BEFORE DIE-OFF	POPULATION ESTIMATE AFTER DIE-OFF	NATIVE OR TRANSPLANTED	TRANSPLANT/ AUGMENTATION DATE(S)
1984	Sun River	900	500	Native	N/A
1999	Ural Tweed	200	<100	Native	Augmented 1963
1997, 2001	Mickey Brandon Buttes	150	50	Transplanted	Transplanted 1980
1995	Kootenai Falls	100	30	Transplanted	1954, 1955
1999	Spanish Peaks	200	<100	Native	Augmented 1944, 1947
1995	Pryor Mountains	250	145	Transplanted	1971, 1974
1994	Highland Mountains	400	12	Transplanted	1967-1969
1994	Tendoy Mountains	150	20	Transplanted	1984-1986, 1996
1991	Lost Creek	400	100	Transplanted	1967
1984	Beartooth Wildlife Management Area	300	50	Transplanted	1971, 1973, 1975
1997	Taylor/Hilgard Mountains	>100	20-30	Native	Augmented 1988, 1989, 1993
1999, 2000	Lower Boulder River	100	2	Transplanted	1985, 1987, 1989, 1995, 1997
2001, 2006	Sleeping Giant	115	39	Transplanted	1992, 1993
2008	Elkhorn Mountains	230	20	Transplanted	1996, 1997, 2000

This table represents some well-documented bighorn die-offs from Montana. At least two of these die-offs occurred among populations (Highland Mountains, Elkhorn Mountains) that had prior contact with domestic sheep (Aune et al. 1998; Byron 2008).

*Appendix E. Best Management Practices Report from Payette National Forest  
Draft Supplemental Environmental Impact Statement, 2009 (USFS 2010b)*

Evaluation of "Best Management Practices"

By Tim Schommer

December 2009



## **Background**

The Payette National Forest (Payette NF) asked me to complete a position statement on the value of "best management practices" (BMPs) related to my past experience. This task is in preparation for their Final Supplemental Environmental Impact Statement (Final SEIS) to the Final Environmental Impact Statement (FEIS) for the Land and Resource Management Plan (LRMP). The SEIS is being prepared for their response to appeal direction received from the Chief's Office of the Forest Service pertaining to bighorn sheep (*Ovis canadensis*) viability, transmission issues between domestic sheep (*Ovis aries*) and bighorn sheep and compliance with the National Forest Management Act and the Hells Canyon National Recreation Area Act.

## **What Are Best Management Practices**

The grazing term "Best Management Practice" has recently been utilized by Idaho State Agencies and the domestic sheep industry as a means to describe on-the-ground practices that reduce the risk of contact between domestic sheep and bighorn sheep where bighorn sheep exist. Many National Forest domestic sheep permittees have been using these practices in some form or another for at least 30 years. In some cases they have been added as terms and conditions to Federal Grazing Permits. LRMPs or Comprehensive Management Plans (CMP) may also include the practices as direction in the form of standards or guidelines. To my knowledge they have not been called BMPs until just recently.

## **Objectives of Best Management Practices**

BMPs would be applied to grazing activities on permitted Federal allotments for several reasons, ranging from utilization levels and range readiness to resource protection. For the issue of disease transmission between domestic sheep and bighorn sheep (BHS), the objective of implementing BMPs is simply to avoid contact at any time between the two sheep species. Any contact may effectively transmit disease, and result in mortality of bighorn sheep. BMPs are designed to reduce the risk of contact by providing for adequate separation. Implemented BMPs that result in contact are ineffective.

Some Forest Service biologists and range conservationists have extensive field experience of where and when these practices are effective. During my role as National Bighorn Sheep Biologist for the Forest Service for the last 18 years, I worked with range conservationists using several of these grazing practices to increase the potential for effective separation. I have assisted approximately 28 National Forests in the western United States in developing and evaluating grazing practices in the field to increase effective separation between bighorn and domestic sheep. I believe I have a unique set of skills and experiences for evaluating BMPs.

## **How to Determine Best Management Practices**

Most annual operating plans/instructions for domestic sheep allotments contain some of these grazing practices. Each allotment includes grazing practices specific to the allotment and permittee and each allotment carries its own set of unique circumstances that need to be evaluated. What works in one location may not work in another. The following factors affect the success or failure of a grazing practice: topography, bighorn sheep source habitat connectivity, bighorn sheep population size, proximity of domestic sheep grazing allotments to bighorn sheep populations, timing of allotment use, density of vegetation, and escape terrain. None of the BMPs discussed below can be determined effective without an active monitoring effort to detect the presence or absence of bighorn sheep near domestic sheep bands. To my knowledge, no peer reviewed literature exists that evaluates the effectiveness of these grazing practices for reducing the risk of contact between the two species.

### Evaluation of Best Management Practices

The following is a list of BMPs that I have used, and the effectiveness that I have seen with each type:

- 1) **Guard Dogs:** Guard dogs are typically added to a band of sheep to help control predators and monitor the domestic sheep. Using guard dogs for keeping bighorn sheep away from domestic sheep has had limited success. These dogs are designed to protect domestic sheep and goats from predators, not other sheep. Some dogs have been quite tolerant of bighorn sheep (see attached photo). It is also hard for guard dogs to be at every location of domestic sheep if they are loosely herded across forested and irregular steep terrain.
- 2) **Extra Herders:** Some operators have added an extra herder. This practice may be of value in open gentle terrain with good visibility. Extra observers will help locate BHS and improve domestic sheep control during daylight hours.
- 3) **Propane Guns:** Using propane guns at the edge of domestic sheep flocks to scare away bighorns has not been successful because most states do not shoot females and young bighorns and have very restrictive ram hunting. Also, bighorns do not regularly associate negative effects with loud noise. Our experience in northeastern Oregon is that deer and elk become conditioned to the noise in 2-3 days and continue to damage crops. Continually moving these propane guns with the bands of sheep is also costly.
- 4) **Trucking of Sheep:** Trucking of domestic sheep instead of trailing has been effective in reducing strays. Strays increase the probability of contact with a bighorn sheep. However, because of cost and the potential for domestic sheep disease associated with this practice, most operators prefer to not truck their sheep.
- 5) **Bedding of Sheep at Night:** Although domestic sheep herders may want to bed the sheep together in a 5-acre area at night, this practice is difficult in steep terrain because sheep are spread out in a "loose herd" fashion and having fenced pens is not realistic. Predators such as coyotes, cougar, and wolves are very effective at killing or scattering domestic sheep at night. In open gentle terrain, this practice can be helpful in controlling domestic sheep.
- 6) **Counting of Sheep:** Most National Forests conduct a 100% count of all domestic sheep onto the allotment at the beginning of the grazing season. Normally, the sheep are not counted during or after the grazing season by the Forest Service. Counting at the end of the season can give an approximation of how many have been killed or lost. Looking for strays during and after the season can reduce the risk of contact with bighorn sheep. Marking domestic sheep is difficult and expensive for the operators. Some operators provide one marker sheep for every 25 head of domestic sheep and count the marker sheep daily. This practice can tell the operator if they are missing any large numbers of domestic sheep. However, this technique has limited effectiveness because it may only take one domestic sheep to transmit disease to bighorn sheep.
- 7) **Herder Communication:** Some operators are now equipping their herders with cell or satellite phones so they can immediately call authorities when bighorn sheep are observed in or close to domestic sheep. Authorities can either shoot, remove, or haze bighorn sheep. These practices can be helpful in preventing contact. However, some operators do not report to authorities when bighorn sheep are near their domestic sheep.
- 8) **Bighorn Monitoring:** Having observers out looking for bighorn sheep is always helpful in keeping the two species apart and radio collars on bighorn sheep can make that effort more productive. However, bighorn sheep monitoring is expensive and not all sheep are collared. Most of the radio collaring has been with conventional collars (VHF) which are usually monitored only twice a month. The new GPS collars report locations several times a day and are more beneficial than VHF collars. However, people need to be mindful of the following aspects: 1) only a sample of the bighorn sheep population is collared; 2) collaring is typically skewed toward ewes, which do not foray as far or as often as rams; 3) nobody knows where the bighorn sheep have been between monitoring efforts with VHF collars; and 4) collaring is expensive.

3. 9) **Sick Domestics:** Not turning sick domestic sheep out on the allotment is standard practice. Unfortunately, the diseases that are transmitted from domestic to bighorn sheep do not make domestic sheep appear sick. While helpful, this practice does not reduce risk of contact or disease transmission.
- 10) **Stray Domestics:** Stray domestic sheep off the allotment need to be quickly removed. Unfortunately, most Forest allotments are in big areas of remote country with some timber where it is hard to detect strays. Many examples exist of strays being out for several weeks without detection. When they are detected, they are often very hard to find and remove. Grazing operators are usually very busy and can't redirect their attention to finding a few strays. Recently, a few operators have been willing to let authorities remove sheep for them under certain conditions. This practice can be helpful in reducing risk of contact, but many strays go undetected.

When all or most of the BMPs are implemented on an allotment, will enough separation be provided to effectively reduce the risk of contact and avoid contact? The key to successful BMPs depends on whether or not BMPs are consistently implemented on the ground, the operators have the ability to maintain tight control of domestics, the allotment is connected to quality bighorn sheep habitat, and bighorn sheep are in or adjacent to the allotment (up to 9 miles).

4. 1) **Implementation:** Agreeing to BMPs on paper is easier; implementing them on the ground for the entire grazing season year after year is more difficult. Many examples of BMPs not always being implemented on the ground exist. And BMPs can only be effective if fully implemented and readily adapted if not working.
- 2) **Maintaining Control of Domestics:** Controlling domestic sheep in terrain that is forested, steep, or rocky is very difficult. In allotments such as the Allison-Berg on the Nez Perce NF, the best possible way to manage vegetation with domestic sheep in this steep rocky terrain is to "loose herd" the sheep-spreading the sheep out over large areas during the day and not tightly controlling them. Such a practice makes it easy for domestics to stray from the herder(s). Visibility is very difficult for the herders, especially in forested habitat and predators such as wolves can cut into the herd and scatter them for miles. Under these situations BMPs are not likely to be effective. The Rock Creek allotment on the Inyo NF is open gentle terrain where a herder can see for miles and can detect bighorn sheep. The Rock Creek Allotment is not in bighorn sheep habitat. BMPs implemented on these types of allotments can be effective in keeping the two species separate and reducing the risk of contact.
- 3) **Bighorn Sheep Habitat and Presence:** Bighorn sheep source habitat is usually in steep, open, rocky terrain as described above where tight control of domestic sheep is usually difficult and herder visibility is limited. In and around the Payette NF, high quality source habitat is not a limiting factor. Habitat is well connected and well distributed across the Payette NF and no natural barriers exist to dissuade bighorn sheep from pioneering, colonizing, and exploring their landscapes as demonstrated by the telemetry and sighting data. This ease of movement for bighorns across the Payette NF leaves questions about the effectiveness of BMPs to successfully provide for avoiding contact or reducing the risk of contact between the two species. Bighorn sheep presence in habitat that is in or adjacent to an allotment makes developing effective BMPs even more difficult. Separation is highly unlikely, and if the allotment is within the herd home range of the bighorn sheep population, contact with the allotment is all but a guarantee. Last year's mixing of a radio-collared ram with domestics on the Allison-Berg Allotment, despite the implementation of BMPs, is an example of their limitations. When bighorn sheep habitat is high quality and continuous for many miles, keeping the two species separate is very difficult.

Although bighorn sheep do not favor timbered areas, they will pass through them and are extremely hard to detect when this happens. Such was the case when a band of domestics was grazing near Josephine Lake on the Payette NF; no one noticed the bighorn sheep ram until it was caught in a wolf snare trap. Without radio collars, bighorn sheep can be very difficult to detect. Even with radio collars, detection on the ground can be difficult. On the Smith Mountain Allotment on the Payette NF, radio collar data showed bighorn sheep located within the allotment during the grazing season without detection by the permittee.

On the Temperance Creek Allotment in Hells Canyon in the 1980s and early 1990s, domestic and bighorn sheep

were separated by over 20 air miles and almost all of the BMPs described above were implemented. Despite these grazing practices and large separation distances, the two species could not be kept apart. Detecting bighorn and domestic sheep in this open, rocky, continuous bighorn sheep habitat was very difficult. Known mixing of the two species approximately every other year resulted in large catastrophic bighorn sheep die-offs.

### **Conclusion**

To avoid disease transmission between domestic and bighorn sheep, contact between the two sheep species should be avoided. In limited situations, implementing BMPs can lead a reduced risk for contact. BMPs that work in one situation may or may not work in another so all BMPs need to be developed for site-specific situations. Connectivity of bighorn sheep source habitat, terrain, density of vegetation, and ruggedness all affect the ability to successfully implement BMPs. Monitoring bighorn sheep presence should be conducted in areas of high risk for contact. Based on my experience, the only significant reduction in risk of contact that I have witnessed is when BMPs are implemented in open, gentle, non-bighorn sheep habitat where domestic sheep can be easily controlled and monitored, and a large buffer exists between the two species.

- 5.
  6. /s/Timothy S. Schommer Date: 12/21/2009
  - 7.
- National Bighorn Sheep Biologist, USDA Forest Service





## Appendix F. BLM and Desert Bighorn Council's 1990 Guidelines (DBC Technical Staff 1990)

### GUIDELINES FOR MANAGEMENT OF DOMESTIC SHEEP IN THE VICINITY OF DESERT BIGHORN HABITAT

Technical Staff  
Desert Bighorn Council

The Bureau of Land Management (BLM) requested that the Technical Staff (Tech Staff) of the Desert Bighorn Council (DBC) prepare management guidelines for domestic sheep in the vicinity of desert bighorn habitat. Desert bighorn habitat includes all geographic areas that would provide for the life requisites of desert bighorn sheep, as defined by state wildlife and/or land management agencies. This request followed a meeting of BLM biologists concerned with problems resulting from interactions between bighorn sheep (*Ovis canadensis* ssp.) and domestic sheep (*O. aries*).

The Tech Staff understands that 2 additional factors should be considered. First, the BLM has prepared, or is preparing, land use planning documents in several western states (Nev., Ariz., Colo., and Ut.) that would allow reintroduction of desert bighorns (*O. c. nelsoni*, *O. c. mexicana*, and *O. c. cremnobates*) into suitable historic habitat. Several potential bighorn reintroductions in Nevada have been contested by the livestock industry; e.g., woolgrowers and cattlemen. They contend that bighorn reintroductions will seriously hamper their ability to graze livestock of their choice on public lands. Second, in 1989, the BLM issued a "Rangewide Plan for Managing Habitat of Desert Bighorn Sheep on Public Lands," which states "Livestock grazing on desert bighorn habitats will be managed via land-use or activity plans to mitigate impacts to desert bighorns and their habitats to ensure objectives for desert bighorn are achieved."

The DBC is comprised of state fish and game and federal agency biologists, private research organizations, academia, and the public. The 4 primary objectives of the DBC are to: provide for the exchange of information on the needs and management of desert bighorns; stimulate and coordinate studies in all phases of the life history, ecology, management and protection, recreational, and economic uses of desert bighorns; provide a clearinghouse for information among all agencies, organizations, and individuals professionally engaged in work on the desert bighorn; and function in a professional advisory capacity, where appropriate, on local, national, and international questions involving the management and protection of desert bighorn.

The DBC's Tech Staff is comprised of 7 elected members. One of the functions of the Tech Staff is to answer requests from agencies and organizations such as the BLM, regarding desert bighorn management.

This document describes problems associated with domestic sheep and bighorn interactions, with emphasis on diseases. Recommendations are then provided to minimize interaction, especially physical contact between domestic and bighorn sheep.

The Tech Staff appreciates the opportunity to consider the problems and develop these guidelines, with the underlying goal of eliminating domestic sheep and bighorn conflicts on public lands.

#### BACKGROUND

Current bighorn numbers are  $\leq 2\%$  of what they were prior to the coming of European man and his livestock and firearms (Wagner 1978). Following enormous population declines in the late 1800s and early 1900s, bighorn populations did not recover, in contrast to other wildlife species such as mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*). Bighorns have demonstrated much less tolerance than other na-

tive North American ungulates to poor range conditions, interspecific competition, overhunting, and stress caused by loss of habitat. Furthermore, they have shown a much greater susceptibility to diseases (Goodson 1982).

Bighorns have died from a wide variety of diseases that they have contracted from domestic sheep. These include scabies (a major cause of mortality in the 1800s and as late as the 1970s in New Mexico), chronic frontal sinusitis, internal nematode parasites (worms), pneumophilic bacteria, footrot, parainfluenza III, bluetongue, and soremouth (contagious ecthyma) (Jessup 1985). Documented bighorn die-offs were recorded as early as the mid-1800s and have continued up to the present (Jessup 1985, Goodson 1982, Foreyt and Jessup 1982, Sandoval 1988, Weaver 1988). Die-off documentation covers not only desert bighorns, but also California bighorns (*O. c. californiana*) and Rocky Mountain bighorns (*O. c. canadensis*). Bighorn die-offs have occurred in every state in the western United States.

In broad perspective, when there has been contact between apparently healthy bighorns and domestic sheep, the bighorns die within a few days to a few weeks. While many diseases or stress factors may be involved, bighorns exposed to domestic sheep almost invariably die from pneumonia.

Little is known about the actual mechanism(s) that lead to the demise of bighorns after they have come into contact with domestic sheep. In all of the cases of bighorn die-offs following direct contact with domestic sheep or overlap of grazing in bighorn ranges, 2 things are apparent.

1. There is a preponderance of evidence (Table 1) strongly linking the presence of domestic sheep with the subsequent loss of part or all of the affected bighorn population. Of the 25 documented cases (Table 1) 4 of the situations were in controlled laboratory experiments in 3 states, and 2 were in situations where bighorns were penned in large paddocks.
2. The effects have all been I way—bighorns have died, while domestic sheep never have suffered ill effects because of coming into contact with bighorn. The prevailing theory on why this has occurred can be summed up as follows: New World sheep (bighorns) are so susceptible to diseases of Old World sheep (domestics) because the bighorns did not co-evolve with the above-listed diseases, as did domestic sheep. Bighorns have not developed effective immunity against these diseases. Domestic sheep are inoculated or, through natural selection over hundreds of years, have developed a resistance against some of these diseases, but carry blood titers for most of them. When there is contact between bighorns and domestic sheep, the bighorns have little defense. This theory is analogous to the accepted explanation for the transmission of human diseases carried to the Native Americans by Europeans. The Native American populations had no immunity to Old World diseases and suffered many documented die-offs.

#### RECOMMENDATIONS

The DBC Tech Staff has reviewed the bighorn sheep problem and developed recommendations for eliminating domestic and bighorn sheep conflicts on public lands. They consist of 1 general recommendation and 4 specific recommendations dealing with buffer strips, livestock supervision, trailing, and reintroductions. Each recommendation is preceded by a statement of the issue, followed by a justification.

##### General Recommendation

**Issue.**—Desert bighorn that come into contact with domestic sheep die as a result of the contact.

**Recommendation.**—Domestic sheep in the vicinity of desert bighorn ranges should be managed so that desert bighorn never come into contact with domestic sheep nor the disease organisms that domestic sheep carry.

**Justification.**—Evidence (Table 1) indicates that contact with domestic sheep is almost invariably lethal to desert bighorn. The recommendations that follow deal with methods to minimize interaction, especially physical contact between domestic and bighorn sheep.

### 34 GUIDELINES

Table 1. Bighorn declines and die-offs resulting from contracts with domestic sheep.

Location	Cause of die-off	Results	Year(s)	Source
Sun River, Mont.		>70 died	1910-35	Goodson (1982)
Upper Rock Ck., Mont.		All died	1965-70s	Goodson (1982)
Thompson Falls, Mont.		All died	1940-60	Goodson (1982)
Kootenay National Park, B.C., Can.	Pneumonia		1939	Goodson (1982)
Bull River, B.C., Can.	Pneumonia	96% died	1965	Bandy (1968) in Goodson (1982)
MacQuire Creek, B.C., Can.	Pneumonia		1981-82	Davidson in Goodson (1982)
Lava Beds National Monument, Calif. <sup>a</sup>	Pneumonia	All died	1980	Blaisdell (1982)
Mormon Mts., Nev.	Pneumonia	50% died	1980	Jessup (1981)
Dinosaur National Monument, Colo.		All died	1950	Barmore (1962) in Goodson (1982)
Rock Creek, Mont.		8 left	1900-20	Goodson (1982)
Rocky Mtn. National Park, Colo.	Pneumonia	All died	1917-30	Packard (1939a, 1939b) in Goodson (1982)
Methow Game Range, Wash. <sup>a</sup>	Pneumonia	13 of 14 died	1979-81	Foreyt and Jessup (1982)
Warner Mt., Calif.	Pneumonia	All died	1988	Weaver (1988)
Oregon	Scabies		1936	Lange (1980)
California	Scabies		1870-79, 1898	Jones (1900) in Lange (1980)
Grey Bull River, Wyo.			1881	Honess and Frost (1942) in Lange (1980)
Wyo., Mont.			1885	Hornaday (1901) in Lange (1980)
Colo.	Scabies		1859-31	Packard (1946) in Lange (1980)
Rocky Mtn. National Park, Colo.	Scabies		1878-1903	Lange (1980)
Latir Parks, N.M.	Pneumonia	All died	1978-82	Sandoval (1988)
Utah St. Univ., Utah <sup>b</sup>	Pneumonia	All died	1970s	Spillett in Goodson (1982)
Univ. B.C., Can. <sup>b</sup>	Pneumonia	All died	1970s	Hebert in Goodson (1982)
Colorado St. Univ., Colo. <sup>b</sup>	Pneumonia	All died	1970s	Hibler in Goodson (1982)
Utah St. Univ., Utah <sup>b</sup>	Pneumonia	4 of 5 died	1988	T. D. Bunch (Utah State Univ., pers. commun.)

<sup>a</sup>Large pen or paddock.

<sup>b</sup>University controlled conditions.

#### Specific Recommendation 1: Buffer Strips

Issue.—Desert bighorn and domestic sheep must be spatially separated to minimize the possibility of these 2 species coming into contact.

No domestic sheep grazing should be authorized or allowed within buffer strips  $\geq 13.5$  km wide surrounding desert bighorn habitat, except where topographic features or other barriers prevent any interaction.

Justification.—Armentrout and Brigham (1988) recommended a 13.5-km-wide separation strip as optimum, based on 9 cited literature sources. Bighorn and domestic sheep separation distances cited in the literature range from 3.2 to 32 km. The California Department of Fish and Game (1983), in its discussion of conflicting land uses, recommended that domestic sheep grazing be eliminated within 3.2 km of bighorn habitat where feasible. The 3.2-km buffer strip also is included in the Mina Habitat Management Plan in Nevada (U.S. Dep. Interior, BLM 1988a) in  $\geq 1$  land-use plan in the Boise, Idaho BLM District (Goodson 1982); and in the Winnemucca, Nevada BLM 1978 grazing Environmental Impact Statement for the Sonoma-Gerlach Resource Area. A 9.6-km-wide buffer strip was recommended in the Lahontan Resource Management Plan (RMP) and the Stillwater Habitat Management Plan in Nevada (U.S. Dep. Interior, BLM 1985, 1986b). The widest recommended buffer (32 km) was used in Arizona. A 32-km buffer was agreed upon in the original Memorandum of Understanding (MOU) between the BLM and Arizona Game and Fish Department. However, when the master MOU was redrafted in 1976, the section relating to domestic sheep grazing in bighorn habitat was not included (Gallizioli 1980). Situations involving potential bighorn and domestic sheep conflicts in Arizona now are handled on a case-by-case basis.

The reason for the 32-km buffer strip was concern over the chronic frontal sinusitis in desert bighorn. This disease occurs when bot fly (*Oestrus ovis*) larvae enter the sinus cavities of bighorns, grow too large to get out, and die, thus infecting the bighorn (Bunch 1978). Sinus cavities in desert bighorns are much larger than those in domestic sheep. The major unanswered question asked by biologists in the 1970s was "what is the range of the bot fly?" Although the U.S. Department of

Agriculture has investigated this question, there is no definitive answer, as it depends upon variables such as temperature, precipitation, and wind. The 32-km buffer strip, however, was felt to be adequate (Gallizioli 1980).

Another problem when considering buffer strips is that young (3-4 yr old) desert bighorn, especially rams, tend to travel extensively ( $\leq 64$  km). Extensive travel by bighorns increases the potential for nose-to-nose contact with domestic sheep. Nose-to-nose contact and resultant transmission of disease(s) was blamed for the catastrophic loss of penned bighorns at the Lava Beds National Monument, California in 1980 (Blaisdell 1982) and in the total population loss of transplanted bighorns in the Warner Mountains, California, in 1988 (Weaver 1988).

Considering all the evidence presented above and cited in Armentrout and Brigham (1988), the Tech Staff feels that buffer strips of  $\geq 13.5$ -km are needed to minimize the potential of disease transmission, including chronic frontal sinusitis, and to avert nose-to-nose contact between wandering bighorns and domestic sheep.

#### Specific Recommendation 2: Livestock Supervision

Issue.—Domestic sheep must be closely and carefully herded to prevent them from straying into desert bighorn range.

Recommendation.—Domestic sheep that are trailed or grazed outside the 13.5-km buffer, but in the vicinity of desert bighorn ranges, should be closely supervised by competent, capable, and informed herders.

Justification.—There is virtually no practical way to control movements of young bighorns, but control of domestic sheep is possible. The key to minimizing impacts by domestic sheep upon bighorns is very close supervision of domestic bands by herding, both while trailing and grazing. Both the Warner Mountains and Lava Beds bighorn die-offs were attributed to stray domestic sheep. Had domestic sheep herding been more intensive, neither of these catastrophes probably would have occurred.

Sheep herders and their control of domestic sheep bands vary considerably. Many herders come to the United States from other countries,



especially South America. Many have never herded sheep before their arrival in the U.S. Permittees who graze domestic sheep on public lands should ensure that their herders are competent and capable and that herders understand the potential problems that may be caused by straying domestic sheep.

The Tech Staff recognizes that the BLM's grazing regulations may need modification to further implement this recommendation. Existing regulations provide that the authorized officer can require herders. The regulations also could be strengthened to allow impoundment of stray domestic sheep, whenever they are found in occupied bighorn habitat. This recommendation could be partially implemented by directives requiring that BLM area managers, range conservationists, and wildlife biologists meet with the permittees and their herders to explain the importance of close supervision by the herders and what could result if domestic sheep are allowed to stray.

#### Specific Recommendation 3: Trailing

**Issue.**—Domestic sheep being trailed near desert bighorn range are likely to transmit diseases to bighorns, especially when ewes are in estrus.

**Recommendation.**—Domestic sheep should be trucked rather than trailed, when trailing would bring sheep closer than 13.5 km to bighorn range. Trailing should never occur when domestic ewes are in estrus.

**Justification.**—Many domestic sheep are still trailed between grazing allotments. The Tech Staff recommends that domestic sheep be trucked whenever possible to minimize possible contact with bighorns. Close supervision by herders is essential. The time of trailing also is important. When domestic ewes are in estrus, they will attract bighorn rams from distances >3.2 km. The Tech Staff recommends, therefore, that domestic sheep not be trailed closer than 13.5 km to occupied bighorn habitat. Domestic sheep also should not be trailed when ewes are in estrus, to reduce potential for bighorn sheep contact. This prescription should be included in BLM grazing regulations as part of the supervision and husbandry requirements.

#### Specific Recommendation 4: Reintroduction

**Issue.**—Ranges formerly occupied by domestic sheep can harbor diseases detrimental to desert bighorn.

**Recommendation.**—Bighorn sheep should not be reintroduced into areas where domestic sheep have grazed during the previous 4 years.

**Justification.**—Our concern involves bighorn reintroductions into habitats formerly occupied by domestic sheep. The Tech Staff does not advocate the co-use of bighorn habitat by both bighorn and domestic sheep. Two diseases that could be transmitted to bighorn after domestic sheep have been removed are footrot and soremouth (Jessup 1985, Kistner 1982). Both of these diseases can lie in the soil and, when conditions are right, be transmitted to bighorns. The soremouth virus can remain viable in the soil for 10 to 20 years (Jessup 1985, Lance 1980).

#### SUMMARY

The DBC Tech Staff herein has identified some of the problems associated with bighorn and domestic sheep interactions, and has rec-

ommended procedures that should eliminate or reduce contact between domestic and desert bighorn sheep. These recommendations include: no nose-to-nose contact between bighorn and domestic sheep; a minimum of a 13.5-km-wide buffer strip between ranges used by domestic sheep and bighorns; trucking of domestic sheep in preference to trailing, and no trailing when domestic ewes are in estrus; and no bighorn reintroductions onto areas that have been grazed by domestic sheep during the previous 4 years.

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*Appendix G. BLM's 1992 Guidelines (BLM 1995a)*

**Guidelines for Domestic Sheep  
Management in Bighorn Sheep Habitats**

The Bureau of Land Management desires progressive bighorn sheep management compatible with appropriate grazing on public lands by domestic sheep.

It is recognized by State and Federal Agencies, bighorn sheep organizations, and the domestic sheep industry that:

- There appears to be some diseases that are shared by domestic and bighorn sheep. There is evidence that if bighorn and domestic sheep are allowed to be in close contact, health problems and die-offs may occur. Some diseases may be transmitted between both species;
- There are bighorn sheep die-offs that occur with no apparent relationship to contact with domestic sheep;
- The above two observations are both valid and not mutually exclusive;
- Bacterial pneumonias are not the only diseases of concern, although perhaps they are the most catastrophic;
- The risks of disease transmission are often unknown; they may, however, be site specific, and;
- Reasonable efforts must be made by domestic sheep permittees and wildlife and land management agencies to minimize the risk of disease transmission, and to optimize preventive medical and management procedures, to ensure healthy populations of bighorn sheep and domestic sheep.

In recognition of the above factors, the guidelines set forth below should be followed in current and future bighorn/domestic sheep use areas.

1. State wildlife and Federal land management agencies, bighorn interest groups, and domestic sheep industry cooperation and consultation are necessary to maintain and/or expand bighorn sheep numbers.
2. When agency and industry agreement has been reached to maintain and/or expand bighorn numbers, the agencies and the domestic sheep industry will be held harmless in the event of disease impacting either bighorns or domestic sheep.
3. Domestic sheep grazing and trailing should be discouraged in the vicinity of bighorn sheep ranges.
4. Bighorn sheep and domestic sheep should be spatially separated to discourage the possibility of coming into physical contact with each other.
5. Buffer strips surrounding bighorn sheep habitat should be encouraged, except where topographic features or other barriers prevent physical contact between bighorn and domestic sheep. Buffer strips could range up to 9 miles (13.5 kilometers) depending upon local conditions and management options.
6. Domestic sheep should be closely managed and carefully herded where necessary to prevent them from straying into bighorn sheep areas.
7. Trailing of domestic sheep near or through occupied bighorn sheep ranges may be permitted when safeguards can be implemented to adequately prevent physical contact between bighorns and domestic sheep.

8. Unless a cooperative agreement has been reached to the contrary, bighorn sheep should only be reintroduced into areas where domestic sheep grazing is not permitted, and the allotment(s) in which bighorns are to be introduced should not have been used for domestic sheep grazing for two or more years prior to the bighorn release.
9. In certain special circumstances, extraordinary precautions will be followed to protect federally listed threatened or endangered subspecies; State listed subspecies; Federal candidate subspecies; and BLM Category II populations (BLM Rangewide Plan for Managing Habitat of Desert Bighorn Sheep).
10. For desert bighorn sheep (*Ovis canadensis nelsoni*, *O.c. mexicana*, and *O.c. cremnobates*), the following additional guidelines are recommended:
  - a. No domestic sheep grazing should be allowed within buffer strips less than 9 miles (13.5 kilometers) surrounding desert bighorn habitat, except where topographic features or other barriers prevent physical contact.
  - b. Domestic sheep trailed and grazed outside the 9 mile (13.5 kilometer) buffer and in the vicinity of desert bighorn ranges should be closely managed and carefully herded.
  - c. Unless a cooperative agreement has been reached to the contrary, domestic sheep should be trucked rather than trailed, when trailing would bring domestic sheep closer than 9 miles (13.5 kilometers) to occupied desert bighorn sheep ranges, especially when domestic ewes are in estrus.
11. These guidelines will be reviewed every 3 years by a work group comprised of representatives from the livestock industry, State wildlife agencies, BLM and bighorn sheep organizations.

## Appendix H. BLM's 1998 Guidelines (BLM 1999)

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### *Attachment 7: Guidelines for Domestic Sheep and Goat Management*

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#### Attachment 7: 1998 Revised Guidelines for Domestic Sheep and Goat Management in Native Wild Sheep Habitats

Note: These guidelines for domestic sheep and goat management in native wild sheep habitats were included as Attachment 1 to BLM Instruction Memorandum No. 98-140 (July 10, 1998). The 1998 revised guidelines were developed following a review of the 1992 Guidelines for Domestic Sheep Management in Bighorn Sheep Habitats (Instruction Memorandum 92-264) in June 1997, and a follow-up meeting of bighorn and domestic sheep specialists in April 1998. Instruction Memorandum 98-140 states that these revised guidelines "should be followed whenever reintroductions, transplants, or augmentations of wild sheep populations, or proposed changes in a livestock grazing permit on BLM administered lands are being considered...."

\* \* \* \* \*

The Bureau of Land Management desires progressive native wild sheep management compatible with appropriate grazing on public lands by domestic sheep and free-ranging goats.

It is recognized by State and Federal agencies, native wild sheep organizations, and the domestic sheep industry that:

- There are some disease agents that occur in both domestic sheep and goats and native wild sheep. There is evidence that if native wild and domestic sheep are allowed to be in close contact, health problems and die offs may occur. Some disease agents may be transmitted between both species. There is evidence indicating that some disease agents could be transmitted between domestic goats and native wild sheep;
- There are native wild sheep die-offs that occur with no apparent relationship to contact with domestic sheep or goats;
- The above observations are both valid and not mutually exclusive;
- Bacterial pneumonias are not the only diseases of concern, although perhaps they are the most catastrophic;
- The risks of disease transmission are often unknown; they may, however, be site-specific; and
- Reasonable efforts must be made by domestic sheep and goat permittees and wildlife and land management agencies to minimize the risk of disease transmission, and to optimize preventive medical and management procedures, to ensure healthy populations of native wild sheep and domestic sheep and goats.

In recognition of the above factors, the guidelines set forth below should be followed in current and future native wild/domestic sheep and goat use areas unless a specific cooperative agreement that includes the State wildlife management agency, the BLM and the livestock permit holder is in place. When such agreement is in place, the agencies and the livestock permit holder will be held harmless in the event of disease impacting either native wild sheep or domestic sheep and

goats.

1. State wildlife and Federal land management agencies, native wild sheep interest groups, and domestic sheep and goat industry cooperation and consultation are necessary to maintain and/or expand native wild sheep numbers. When agency and industry agreement has been reached to maintain and/or expand native wild sheep numbers, the agencies and the domestic sheep industry will be held harmless in the event of disease impacting either native wild sheep or domestic sheep and goats.
2. Domestic sheep or goat grazing and trailing should be discouraged in the vicinity of native wild sheep ranges.
3. Native wild sheep and domestic sheep or goats should be spatially separated to reduce the potential of interspecies contact.
4. In reviewing new domestic sheep or goat grazing permit applications or proposed conversions of cattle permits to sheep or goat permits in areas with established native wild sheep populations, buffer strips surrounding native wild sheep habitat should be developed, except where topographic features or other barriers minimize physical contact between native wild sheep and domestic sheep and goats. Buffer strips could range up to 13.5 kilometers (9 miles) or as developed through a cooperative agreement to minimize contact between native wild sheep and domestic sheep and goats, depending upon local conditions and management options.
5. Domestic sheep and goats should be closely managed and carefully herded where necessary to prevent them from straying into native wild sheep areas.
6. Trailing of domestic sheep or goats near or through occupied native wild sheep ranges may be permitted when safeguards can be implemented to adequately prevent physical contact between native wild sheep and domestic sheep or goats. BLM must conduct on-site use compliance during trailing to ensure safeguards are observed.
7. Cooperative efforts should be undertaken to quickly notify the permittee and appropriate agency to remove any stray domestic sheep or goats or wild sheep in areas that would allow contact between domestic sheep or goats and native wild sheep.
8. Unless a cooperative agreement has been reached to the contrary, native wild sheep should only be reintroduced into areas where domestic sheep or goat grazing is not permitted.
9. Extraordinary precautions will be followed to protect special status subspecies, e.g., federally listed threatened, endangered, proposed and candidate subspecies, State listed subspecies and BLM sensitive subspecies.
10. For desert bighorn sheep, (*Ovis canadensis nelsoni*, *a.c. mexicana*, and *a.c. cremnobates*), the following additional guidelines are recommended:

- a. No domestic sheep or goat grazing should be allowed within buffer strips less than 13.5 kilometers (9 miles) surrounding desert bighorn habitat, except where topographic features or other barriers prevent physical contact.
  - b. Domestic sheep or goats trailed and grazed outside the 13.5 kilometers (9 mile) buffer and in the vicinity of desert bighorn ranges should be closely managed and carefully herded.
  - c. Unless a cooperative agreement has been reached to the contrary, domestic sheep or goats should be trucked rather than trailed, when trailing would bring domestic sheep or goats closer than 13.5 kilometers (9 miles) to occupied desert bighorn sheep ranges, especially when domestic ewes or nannies are in estrus.
11. These guidelines will be reviewed at least every 5 years by a work group comprised of representatives from the domestic sheep and goat industry, State wildlife agencies, BLM and native wild sheep organizations.

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